

The AMSAT[®] Journal

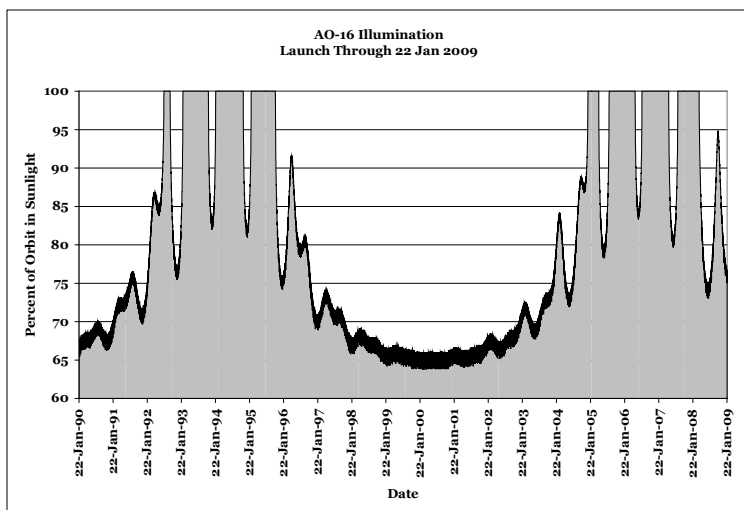


Editor-in-Chief:
Ed Long, WA4SWJ

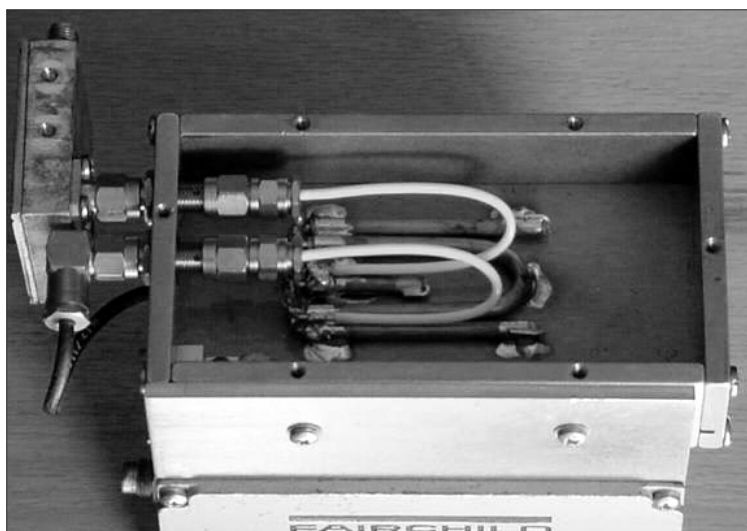
Assistant Editor:
Bill Hook, W3QBC

Volume 31, Number 2

March/April 2008



AO-16 is Back!



2.4 GHz Source

AMSAT-NA
850 Sligo Avenue, Suite 600
Silver Spring, MD 20910-4730

Periodicals

POSTAGE PAID

At Silver Spring, MD
and at additional
mailing offices

in this issue

AMSAT Announcements2

Apogee View3

by Rick Hambly • W2GPS

Modification of a CDE Tail4

Twister Control Unit for
Satellite Tracking

by Domenico Marini • I8CVS

2.4 GHz Source Using a9
Brick Oscillator VCO

by John M. Franke • WA4WDL

The Courteous Ham's Guide 11
to AO-51, v1.1

by Ben Jackson • N1WBV
and John Marranca, Jr. • KB2HSH
and Charles Reiche • N3CRT
and Mark Vande Wetering • KF6KYI

2008 AMSAT Field Day 12
Competition

by Bruce Paige • KK5DO

The Orbital Classroom, #13 16
National Science Education
Standards

by H. Paul Shuch • N6TX

Successful AMSAT Activities 19
at 2008 Greater Houston Hamfest

by Allen F. Mattis • N5AFV

Remembering Sir Arthur C.21
Clarke

by H. Paul Shuch • N6TX

Amsat's New Spacecraft.....23
Integration Lab After 14 Months

by Robert Davis • KF4KSS
and J.C. Taylor • W3JCT

A Second Life for AO-16:27
Crash - Recovery - Rebirth

by Mark Hammond • N8MH
and Jim White • WD0E
and Bruce Rahn • WB9ANQ

How You Can Help Build New and Exciting Satellites

Donate to the President's Club

Gold, Silver, Bronze and Core levels are available to match your ability to participate.

Cash Gifts

Visa, or MasterCard or checks are accepted. And, you can specify how your contribution is to be used.

Gift of Life Insurance

US taxpayers may be able to receive a significant income tax deduction by making The Radio Amateur Satellite Corporation the owner and beneficiary of life insurance policies.

Gift of Stocks or other Securities

US taxpayers should be able to avoid capital gains taxes on appreciated securities and receive a deduction for their fair market value.

Bequest

A codicil in your will, naming The Radio Amateur Satellite Corporation as a beneficiary will help insure the continuance of the Amateur Radio Satellite program.

Call the AMSAT-NA office at 301-589-6062 for questions on any or all of these ways you can help build new and exciting satellites.

Support AMSAT-NA

AMSAT Announcements

Board of Directors Nominations

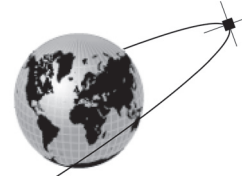
It is time to submit nominations for the upcoming open seats on the AMSAT-NA Board of Directors. A nomination requires either one Member Society or five current individual members to nominate an AMSAT member for the position. A director serves for a period of two years. Three director's terms expire this year: Tom Clark, K3IO, Lou McFadin, W5DID, Bob McGwier, N4HY. Nominations must be in writing and mailed to: AMSAT, 850 Sligo Ave #600, Silver Spring, MD 20910. They can arrive no later than June 12, 2008.

AMSAT's Mission

AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow Amateur Radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.

AMSAT's Vision

Our Vision is to deploy high earth orbit satellite systems that offer daily coverage by 2009 and continuous coverage by 2012. AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups.



Radio Amateur Satellite Corporation (AMSAT-NA)
850 Sligo Ave., Silver Spring, MD 20910-4703
Telephone: 301-589-6062 – Toll Free: 888-322-6728
Facsimile: 301-608-3410

AMSAT-NA Club Callsign: W3ZM
AMSAT-NA Web site: <http://www.amsat.org>

The AMSAT Journal Staff

Editor-in-Chief: Ed Long, WA4SWJ, wa4swj@amsat.org
Assistant Editor: Bill Hook, W3QBC
Circulation: Martha Saragovitz, martha@amsat.org

AMSAT-NA Board of Directors

Barry Baines, WD4ASW, wd4asw@amsat.org
Tom Clark, K3IO, k3io@amsat.org
Drew Glasbrenner, KO4MA, ko4ma@amsat.org
Rick Hambly, W2GPS, w2gps@amsat.org
Lou McFadin, W5DID, w5did@amsat.org
Bob McGwire, N4HY, n4hy@amsat.org
Günther Meisse, W8GSM, w8gsm@amsat.org

AMSAT-NA Senior Officers

President: Richard Hambly, W2GPS
Executive Vice-President: Lee McLamb, KU4OS
Treasurer: Günther Meisse, W8GSM
Corporate Secretary & VP Special Projects:
Barry Baines, WD4ASW
Manager: Martha Saragovitz
Vice-President, Engineering: Bob McGwier, N4HY
Vice-President, Operations: Drew Glasbrenner, KO4MA
Vice-President User Services: Gould Smith, WA4SXM
Vice President, Marketing: Dan Briner, AB3BN

Honorary Positions

Immediate Past President: Robin Haighton, VE3FRH
President Emeritus: Tom Clark, K3IO
Founding President: Perry Klein, W3PK

Editorial Office: Ed Long, WA4SWJ, 6685 Southeast 108th Street, Belleview, FL, 34420-3449. Please e-mail Journal submissions to: journal@amsat.org, telephone: 262-374-1349. **Advertising Office:** AMSAT-NA Headquarters, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703.

The AMSAT Journal (ISSN: 1407-3076) is published bi-monthly (Jan/Feb, Mar/Apr, May/Jun, Jul/Aug, Sep/Oct, Nov/Dec) by AMSAT-NA, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703. Telephone: 301-589-6062, fax: 301-608-3410. Periodicals postage paid at Silver Spring, MD and additional mailing offices.

Postmaster: Send address changes to *The AMSAT Journal*, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703.

Opinions expressed in *The AMSAT Journal* are those of the article authors and are not necessarily those of AMSAT-NA. Copyright © 2008 by AMSAT-NA, The Radio Amateur Satellite Corporation. AMSAT is a registered trademark. Reproduction of material from *The AMSAT Journal* by mechanical, electronic, photocopy or other means is prohibited unless written permission is obtained from the author.

The AMSAT Journal staff is always interested in article submissions. Whenever possible, submissions should be sent via e-mail to journal@amsat.org using plain text or word processor files; photos or figures in TIF, GIF or JPEG formats. AMSAT-NA reserves the right to select material for *The AMSAT Journal* based on suitability of content and space considerations. The editors of this publication are volunteers giving freely of their talents, time and efforts to produce *The AMSAT Journal*.

AMSAT at the Races

AMSAT officials Rick Hambly, W2GPS, Tom Clark, K3IO, and Gould Smith, WA4SXM, attended the Rolex Daytona Prototype Bosch Engineering 250 at Virginia International Raceway in Alton, VA on April 26, 2008 for the first ever appearance of AMSAT's name on a professional race car. The car was driven by Brad Jaeger, the son of AMSAT member Jim Jaeger, K8RQ. A picture and more information are on page 17.

AMSAT at Dayton

As I write this I am packing for the Dayton Hamvention. Unfortunately, by the time you read this, the Hamvention will already be over. We are looking forward to another great year at the Hamvention. AMSAT's booth will again be expanded so we will have plenty of space for displays and meetings as well as the traditional sales area. I hope to greet many of you in person and hear your comments and suggestions.

AMSAT Member and Astronaut Dr. Ronald A. Parise, WA4SIR, SK

It is with profound sadness that I learned of the passing of my friend and AMSAT member Ron Parise, WA4SIR. When Ron was diagnosed with cancer he recommended me to fill in for him on the design team for his brainchild, the MidSTAR-1 satellite project at the US Naval Academy. There I had the honor of working with Ron's students and colleagues. The MidSTAR-1 student satellite was successfully launched in March 2007 and continues to work well. On March 8, 2008 the design team held a first anniversary celebration at Ron's house where we shared our champagne with Ron's family. I relinquish the rest of my space this month to the obituary written by Ron's close friend and AMSAT VP Human Spaceflight, Frank Bauer, KA3HDO.

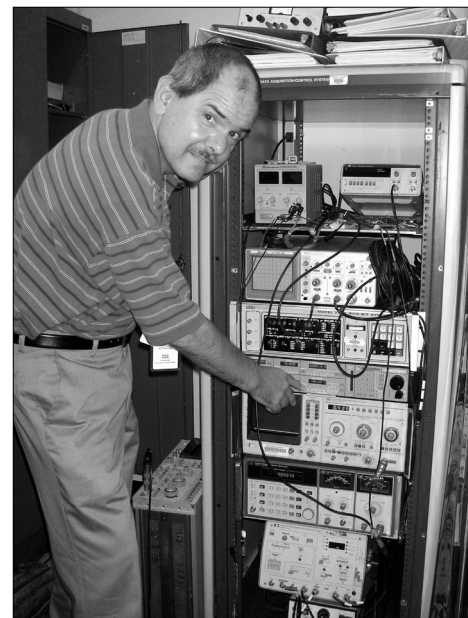
73,
Richard M. Hambly, W2GPS
AMSAT President

It is with a heavy heart that I announce the passing of a great friend, colleague and fellow ham radio operator Dr. Ronald A. Parise, WA4SIR, left this Earth today, Friday May 9, 2008 after a very long and courageous battle with cancer.

Ron Parise was, and continues to be, an inspiration to countless students, ham radio operators, and friends the world over. His accomplishments were many, including:

space explorer, pioneer, astrophysicist, pilot, ham radio operator, avionics and software expert, inspirational speaker and motivator, student satellite mentor, husband, father and friend. While he certainly did some truly extraordinary things in his lifetime, Ron Parise is best known and cherished for keeping family and friends first, and for this, we will miss him most.

Ron flew as a payload specialist on two Space Shuttle missions: STS-35 on the Space Shuttle Columbia in December 1990 and STS-67 on the Space Shuttle Endeavour in March 1995. These two missions, called ASTRO-1 & 2 respectively, carried out Ultraviolet and X-ray astronomy observations. He logged over 614 hours and 10.6 million miles in space. Ron and his crewmembers on ASTRO-1 became the first astronomers to operate a telescope from space, making hundreds of observations during the mission. His personal contributions to these two missions have provided scientists with an unprecedented view of our universe, expanding our understanding of the birth, life and death of stars and galaxies.



Ron was also the ultimate ham radio operator, in space and on the ground. First licensed when he was 11, Ron kept the Amateur Radio hobby at the forefront of everything he did, including his operations from space. During his two Space Shuttle flights, he talked to hundreds of hams on

continued on page 17 ...



Modification of a CDE Tail Twister T2X Control Unit for Satellite Automatic Tracking

by Domenico Marini, I8CVS, domenico.i8cvs@tin.it

Introduction

The CDE family of rotators is very popular and the Tail Twister T2X model is a very sturdy azimuth rotator that can be modified with ease for azimuth automatic satellite tracking in those existing installations where minor changes and cost are important.

Theory of Operation and Function

How to get the Position Voltage Feedback from the Rotator Potentiometer R3.

The schematic diagram shown in Figure 1 reveals that the 500 ohm linear potentiometer R3 mounted inside the rotator is originally connected across terminals 3 and 7 of the control unit and the wiper of R3 is internally grounded to terminal 1. The output of the meter transformer (23 volt AC) is rectified by CR1 and then stabilized by the 13 volt

zener diode VR1 so that a voltage of about 12.8 volts DC is applied across terminals 3 and 7 of the potentiometer, which is used as the angular position transducer via the calibrated current flowing through the meter I (1 mA full scale).

Terminal 3 on the board is a positive voltage of +12.83 volts DC with respect to terminal 7, while the terminal 7 is a negative voltage of -12.83 volts DC with respect to terminal 3. It is very important that terminals 3 and 7, which are directly connected across the potentiometer R3, are kept floating, i.e., they are insulated from the ground that is available at terminal 1.

Since terminals 3 and 7 of the board are floating, if we disconnect R3 from the board and we connect terminal 7 to ground, then

a positive voltage of +12.83 volts DC will appear between terminals 3 and 1 of the board.

With this in mind we see that the wiper of the 500 ohm potentiometer R3 has been internally grounded inside the rotator and, in addition, it has been connected to ground terminal 1 of the board through lead #1 of the control cable. In this condition, when the rotator is turned fully CW, the wiper of R3 comes into contact with terminal 7. That becomes the ground reference point so the voltage measured between terminal 3 and ground 1 is a positive voltage of about +12.83 volts DC.

On the other hand, when the rotator is turned fully CCW the wiper of the potentiometer comes in to contact with terminal 3 that

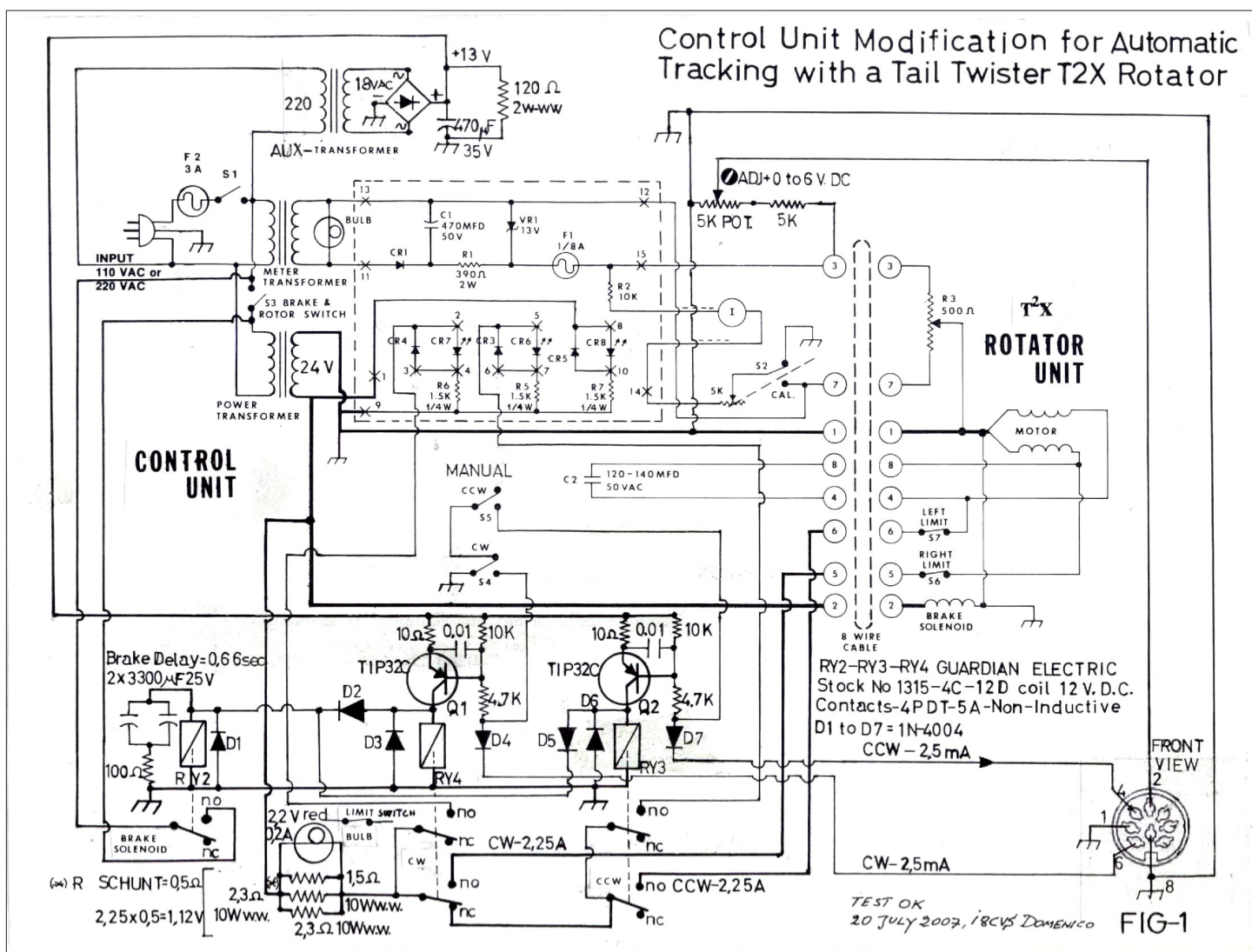


Figure 1: Schematic of the modified rotator control.

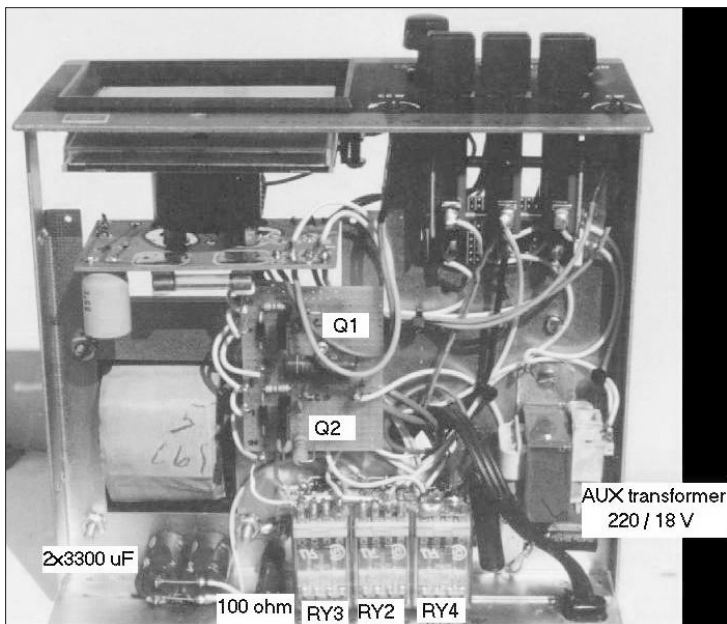


Photo 2: T2X control unit bottom view.

becomes the ground reference point so that the voltage appearing between terminals 3 and ground 1 is 0 volts. It follows that by turning the rotator by 360 degrees a positive voltage linearly changing from 0 volts fully CCW to +12.83 volts DC fully CW is available between terminals 3 and ground 1 of the board.

Now if we connect a 5k fixed resistor between terminals 3 and ground 1 in series with a 5k potentiometer, then turning the rotator by 360 degrees, a maximum positive voltage changing from 0 to about 6 volts DC will appear between the hot end of the 5k potentiometer and ground as shown by the

azimuth antenna rotation by 360 degrees.

Note that connecting a 5k fixed resistor in series with a 5k potentiometer between terminal 3 and ground does not affect the original meter accuracy because the internal resistance of the 500 ohm potentiometer R3 as seen as a source is very low with respect to the high resistance of the load associated with the meter circuit connected in parallel to R3, and in fact the constant current of $12.83/500 = 25.6$ mA flowing through the 500 ohm potentiometer is enormously greater than the maximum possible current of 1mA flowing through the internal resistance of the moving coil of the meter, which in turn is in series with a 10 k fixed resistor R2 plus the 5k calibration potentiometer.

schematic diagram in Figure 1.

Finally the maximum positive voltage available between the wiper of the 5k potentiometer and ground can be precisely adjusted to +5 volts DC and sent via a 8 pole DIN connector (Photo 9) to any standard automatic tracking interface to be used as a position voltage feedback linearly changing from 0 to +5 volts DC according to a corresponding

the rotor CW while the switch S-5 allows the motor to rotate the rotor CCW.

Incidentally, the procedure of manually pressing S-3 first and then S-4 or S-5 is not mandatory and in practice when the rotor is stationary, both switches S-3 plus S-4 or S-3 plus S-5 can be depressed at the same time to release the brake and run the motor.

The original manual switching circuit of this control box is a simple design using three very robust SPST switches developed as limit switches for industrial purposes. But because of the SPST limitation, both S-4 and S-5 cannot be mechanically or electrically interlocked to prevent depressing S-4 and S-5 at the same time. Should this condition occur, it would allow both the CW and CCW motor windings to be energized with 24 volt AC power at the same time with both the red lamps lighted ON and with the rotor stuck since it is trying to move in two directions at once.

Examining the original circuit in more detail, we see that when S-4 is in the normally closed position and the motor is not running, the two diodes CR4 plus the red LED CR7 are shorted out by S-4 so that CR7, which is used for CW running indication, is OFF but as soon S-4 is depressed then its normally open contact closes and the common of S-4 sends 24 volt AC power supply to terminal 5 of the motor.

In this condition the rotor runs CW, but at the same time the normally closed contact of S-4 opens and the diodes CR4 and CR7, which are connected in anti-parallel, now supply 24 volts AC power via resistor R6 and so the red LED CR7 is ON indicating that the motor is running CW.

The same circuit is used for the CCW switch S-5 together with the diodes CR3 and the red LED CR6. Both are connected in anti-parallel for CCW ON indication.

The Original Motor Switching Circuit

The original control unit available in the owner's manual has been designed only for manual operation through the lever switches S-3, S-4 and S-5. The switch S-3 is used to first release the 24 volt AC solenoid brake. After the brake wedge has been retracted the switch S-4 allows the motor to rotate

The Modified Motor Switching Circuit for Automatic Tracking

As shown by the schematic diagram in Figure 1 the original switches S-3, S-4 and S-5 for manual operation have been now electrically interlocked for safety, but they are only used to excite the coils of three 12 Volt DC relays through PNP switching transistors Q1 and Q2 (type TIP32C). The relay RY3 is used to supply power to the motor for CCW operation while relay RY4 is used to supply power to the motor for CW operation.

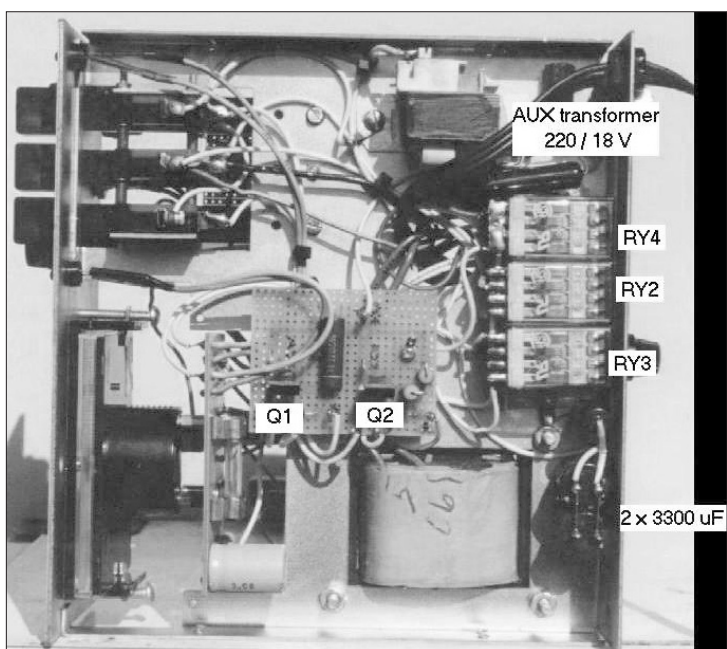


Photo 3: T2X control unit chassis bottom view.

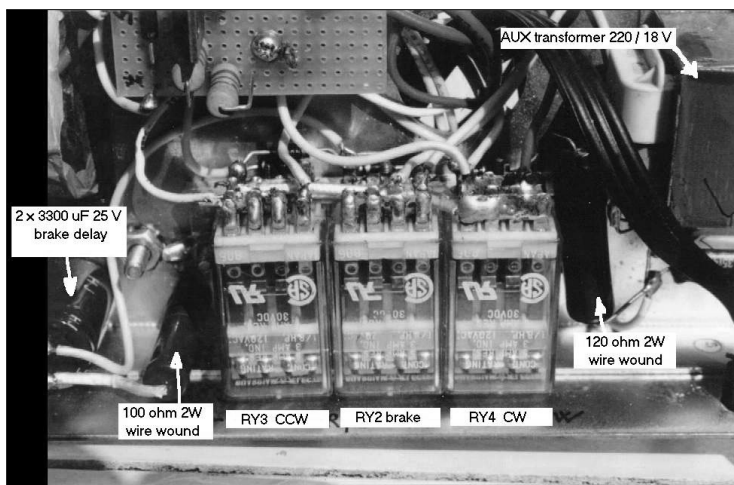


Photo 4: T2X control unit detail of relay positioning.

For safety purposes the normally closed contacts of relay RY4 are also electrically interlocked with the common of relay RY3 so that both windings of the motor may not be supplied with power at the same time. The relay RY2 is used only to switch ON the power transformer primary, which is used to supply 24 volts AC to the brake solenoid plus the windings of the motor for CW or CCW rotation.

4 or automatically low if grounded via D4 through the computer interface, then the emitter-collector junction of Q1 is conducting and 12 volts DC is applied across the coil of RY4. Also, 12 volts DC is applied to the coil of brake relay RY2 through the diode D2 so that the brake solenoid is excited and the rotator is allowed to run CW.

Note that when Q1 is conducting, only RY4 and RY2 can be excited and when Q2 is conducting only RY3 and RY2 can be excited because the current flowing from the collector of Q1 to the coil of RY2 via diode D2 cannot flow back from the cathode towards the anode of D5 to concurrently excite RY3. So the possibility of powering the motor CW and CCW windings at the same time is

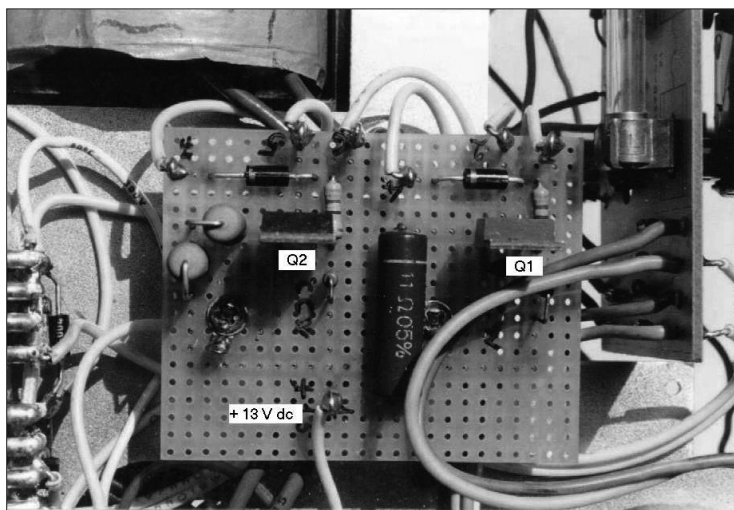


Photo 5: T2X control unit detail of Q1 and Q2 perforated board.

To obtain manual or automatic operation using relays, the normally open contact of RY2 has been connected in parallel with the normally open contact of the manual switch S-3. This has the purpose of supplying the power transformer 220/24 volts as required for automatic or manual operation.

During manual or automatic operation when the base of Q2 is kept manually low as grounded via S-5 or automatically low if grounded via D7 through the computer interface, then the emitter-collector junction of Q2 is conducting and so 12 volts DC is

prevented.

The “Operating Practice” chapter of the manual, point 3, recommends: “Upon completion of turning, always allow the rotor to coast down by keeping your finger on the “Brake Release” after you have released the rotation lever. This procedure will allow the rotator to stop before you re-engage the brake wedge. Observing this sequence prevents the rotator from stopping suddenly thus preventing undue stress on the rotator, beam, and tower”.

applied across the coil of RY3. Also, 12 volts DC is also applied to the coil of the brake relay RY2 through diode D5 so that the brake solenoid is excited at the same time with the motor relay RY3 and the rotator is allowed to run CCW.

Similarly, when the base of Q1 is kept manually low as grounded via S-4 or automatically low if grounded via D4 through the computer interface, then the emitter-collector junction of Q1 is conducting and 12 volts DC is applied across the coil of RY4. Also, 12 volts DC is applied to the coil of brake relay RY2 through the diode D2 so that the brake solenoid is excited and the rotator is allowed to run CW.

To automatically actuate this important procedure the brake relay RY2 dropout has been delayed by about 1 second by connecting two 3300 uF capacitors in parallel and in series with a 100 ohm resistor across the coil of RY2 to get a time constant RC of about 0.66 seconds. Obviously the time constant can be increased by increasing the capacitor values according to the weight and inertia of the antenna.

During operation when the supply voltage to excite RY2 lasts a short time of say few milliseconds, then the capacitor has not the time to fully charge. So, as soon as the command stops, then RY2 suddenly opens and immediately the brake wedge is safely re-engaged because the inertial energy stored in to the antenna is very small and the developed torque is not able to generate undue stress to damage the gear box.

On the other hand when the voltage to excite RY2 lasts a time longer than 1 second to rotate the antenna by a few degrees, then the capacitor has the time to fully charge itself. But as soon as the running command stops then RY3 or RY4 release immediately cutting the motor current, but RY2 stays excited until the capacitor across the coil discharges itself through the 100 ohm resistor. When RY2 releases, the brake wedge will re-engage again but only after about 1 second or more depending on the capacitor value as determined by the specific inertia of the antenna when the rotator gears are already completely stationary.

In the schematic diagram (Figure 1) there are three 10W wire-wound resistors of 1.2, 2.3 and 2.3 ohms in parallel to form a 0.5 ohm resistor. They are connected in series with the motor so that when the motor is running at 2.25 amperes a voltage drop of $2.25 \times 0.5 = 1.12$ volts is developed across the 0.5 ohm resistor. This voltage is applied to a red bulb 2.2 V 0.2A connected as a shunt to indicate in the front panel that the motor is actually running. This is very useful, particularly to check the efficiency of the left and right limit switches S7 and S6 respectively.

Construction

The schematic diagram in Figure 1 is a straightforward guide to wire the circuit. Begin by finding three suitable relays for RY2, RY3 and RY4. In this prototype the relays are Guardian Electric 1315 Series with 12 volt DC coils, type A410-362626-12, stock No 1315-4C-12D, but they were used only because many of them were available in my junk-box.

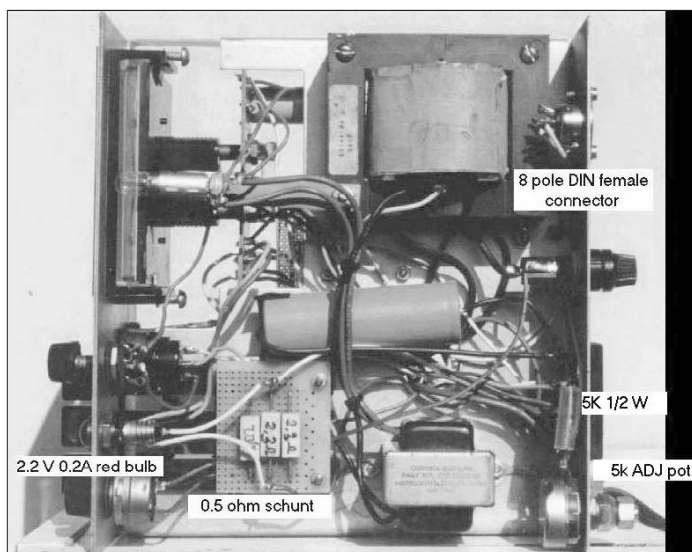


Photo 6: T2X control unit top view.

The contacts of these relays are 4PDT, i.e. four-pole double throw with a continuous rating of 5 amperes resistive, 30 volts DC or 3 amperes inductive designed to switch ON/OFF an AC motor, 1/8 HP at 120 volts AC. So I have used the NO and NC contacts of three contacts connected in parallel to run the motor and one contact is used to switch the CCW and CW LED's on the front panel ON or OFF. Since the current flowing into the windings of the T2X motor is 2.25 amperes, it follows that any similar DPDT relay rated at 3 amperes inductive with a 12 volt DC coil can be used. The best point to place RY2-RY3 and RY4 is on the bottom side of the chassis, which has plenty of room over the metal surface of the back panel as shown by Photos 2, 3 and 4.

As shown in Photo 4, sockets to mount the relays were not available so RY2, RY3 and RY4 were mechanically mounted on a small aluminum angular plate following

more detail in Photo 5. This circuit should be tested separately before mounting it on the chassis.

Following the schematic diagram in Figure 1, connect one end of each coil of RY2, RY3 and RY4 to ground. The other end of RY2 is connected to both cathodes of D1 and D2. The collector of Q1 is connected to the other end of RY4 and the collector of Q2 is connected to the other end of RY3. When assembly of this circuit is complete, after the cathode of D4 is grounded, both relays RY2 and RY4 must activate with a current of 2.5 mA between D4 and ground. Similarly, grounding the cathode of D7 both relays RY2 and RY3 must activate with a current of 2.5 mA between D7 and ground.

The AUX 220 / 18 volt transformer that was added is used to supply 12 volt DC power at 300 mA for the coils of RY2-RY4 and RY3. Any suitable transformer available in the junk box can be used and as shown in Photos 2 and 3. It was been placed in a corner of the bottom of the chassis with the associated bridge rectifier, a 470 uF 35 volt filter capacitor and a 120 ohm 2 W bleeder resistor for voltage regulation.

The 1.2 – 2.3 – 2.3 ohm resistors are connected in parallel to form a 0.5 ohm resistor in series with the motor and are mounted near the red pilot lamp on a piece of

perforated board in the upper compartment of the chassis as shown in Photos 6 and 7.

The red pilot lamp that indicates that the motor is running and the limit switches are closed has been placed in the front panel over the center brake release lever switch and is shown in Photo 10.

The 5k potentiometer and the 8-pin DIN connector have been placed on the back side of the control box as visible in Photo 9 and is shown in more detail in Photo 8.

Wiring the Circuit

The printed circuit board assembly, part number 5139200, must be modified from the original schematic diagram available in the owner's manual, but it is not strictly necessary to remove it from the meter. Using an X-ACTO knife cut the copper strip between the anode of CR7 and the cathode of CR3 and similarly cut the copper strip between the anode of CR6 and the cathode of CR5. Unsolder the wire from stud number 3 of the board going to the normally closed contact of the manual switch CW S4. Unsolder the wire from stud number 6 on the board going to the normally closed contact of the switch CCW S5. Be sure that the cathode of CR4 and the anode of CR7 are both connected to stud number 2 and be sure that the cathode of CR3 and the anode of CR6 are both connected to stud number 5. Check that the cathode of CR5 and the anode of CR8 are both connected to stud number 8 and to stud number 1 going to 24 volts AC.

The rest of the circuit can be wired following the schematic diagram in Figure 1 using any preferred familiar method. Since the wiring of all components cannot be made in a single step, the preferred method is to make an enlarged photocopy of Figure 1 and mark on it as every new soldered wire is added overlapping the drawing using a red pencil to show that the connection has been made.

Test and Calibration

Double check the new wiring and if all voltages are correct connect the rotator to the control unit. Manual operation is accomplished using the lever switches as in the original control box, but check to make sure the CCW and CW rotations correspond to the indications on the front panel.

It does not matter if the "Brake Release" center lever is pressed first because relay RY2 activates the brake solenoid as soon RY4 or RY3 are excited and the motor begins running. By the way, the original procedure

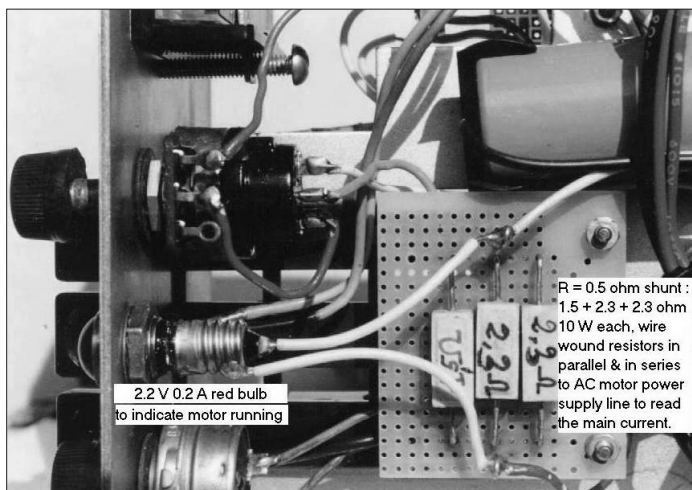


Photo 7: T2X control unit detail of shunt pilot lamp.





I use a modified T2X for azimuth along with a modified Kenpro KR500 for the elevation using the same relay switching circuit.

- 1) Tail Twister Model T2X-Rotator
Owner's Manual
- 2) Instruction Manual G-5500



2.4 GHz Source Using a Brick Oscillator VCO

John M. Franke, WA4WDL, jmfranke@cox.net, (AMSAT #10211)

I needed a 2.4 GHz marker generator. Using a TTL oscillator with or without a diode harmonic generator works fine, but it generates a plethora of weak signals separated by the oscillator frequency. I wanted something that had a stronger output and did not produce spurious signals.

So called brick oscillators have been a long time favorite with microwave experimenters. However, finding a brick oscillator covering 2.4 GHz proved to be difficult. So, I did the next best thing; I modified an existing brick oscillator. Brick oscillators use an internal or external reference crystal oscillator operating between 90 and 112 MHz. A voltage controlled oscillator, VCO, is phase-locked to a harmonic of the reference oscillator. The VCO typically operates somewhere between 1 and 2.5 GHz. The VCO is followed by a SRD (step recovery diode) frequency multiplier and a comb line bandpass filter. The SRD stage is typically used to multiply the VCO output frequency by a factor of between 2 to 9. The overall frequency multiplication of the reference frequency is typically between 25 and 110. I looked through my junk box for a brick having a VCO covering 1.2 GHz. The plan was that I could double the VCO output frequency with an external frequency doubler to get 2.4 GHz. The following bricks looked interesting:

Freq. (GHz)	Multiplication	Xtal Range (MHz)	VCO range (GHz)	Xtal for 2.4 GHz (MHz)
3.6 - 3.9	36(12X3)	100.0 - 108.4	1.200 - 1.300	100.000
4.33 - 4.93	44(11X4)	98.4 - 112.1	1.082 - 1.233	109.091
4.6 - 4.93	44(11X4)	104.5 - 112.1	1.15 - 1.233	109.091
4.8 - 5.32	48(12X4)	100.0 - 110.83	1.2 - 1.33	100.000
5.855 - 6.105	60(12X5)	97.6 - 101.8	1.171 - 1.221	100.000

I selected a Fairchild model MSS-42XC-01, which has an output frequency of 3.6 – 3.9 GHz. The brick came with an internal reference oscillator using a TO-5 case 100.0568 MHz crystal in a crystal oven. The VCO frequency is twelve times the reference frequency or 1200.682 MHz. Tune-up was a breeze without any problems. The crystal oscillator adjustment was smooth and the VCO tuned easily and broadly to the desired frequency.

I removed the SRD tripler block. I sawed and filed a 1-1/4" by 3 inch piece of 1/8"

thick aluminum plate to replace the SRD multiplier as shown in Photo A. I used the old SRD tripler block to mark the location of mounting holes and the SMA output connector. The SMA connector is mounted with four 2-56 screws threaded into the plate. For a coupling probe, I soldered a 3/16" across flats brass 4-40 nut on the SMA center conductor. The end of the nut is 7/32" above the new plate.

Next, I needed a frequency doubler. Since the VCO output is typically strong, I decided to use a passive frequency doubler. I fabricated a full wave, diode frequency multiplier using semi-rigid coaxial cable and two common 1N82A UHF silicon diodes, see Figure 1. 1N82A diodes were once popular mixer diodes used in UHF television converters. A full wavelength at 2400 MHz is 4.92 inches, half-wavelength is 2.46 inches, and one quarter wavelength is 1.23 inches. A full wavelength at 1200 MHz is 9.84 inches, half-wavelength is 4.92 inches, and one quarter wavelength is 2.46 inches.

The 1.2 GHz half wave balun is formed with 3.44 inches of RG-141 (velocity factor = 0.70). Three quarter-wave stubs are used as RFCs and dc returns. Two stubs, tuned to 1.2 GHz, are placed at the ends of the half wave balun and the third stub, tuned to 2.4 GHz, is across the multiplier output connection. The two 1.2 GHz quarter-wave stubs are formed from 1.72 inch lengths of RG-141. The single 2.4 GHz quarter-wave stub is formed from a 0.86 inch long piece of RG-141.

I used a piece of G-10 doubled-sided printed

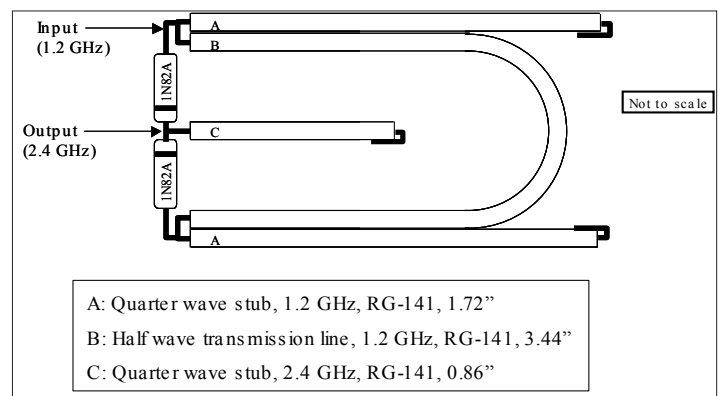


Figure 1: Full wave frequency doubler.

circuit board for the ground plane. Single sided board material would work equally well. I just used what I had on hand. I cleaned one board, drilled the bracket holes, and mounted the board in a shielded enclosure salvaged from a Transit satellite navigation receiver. I tack soldered the RG-141 lines to the ground plane, added the 1N82A diodes, and soldered input and output coax cables in place as shown in Photo B. Replacing the input and output cables with stripline to the input and output connectors would reduce the size of the doubler and the losses. The results were good enough, so I did not rebuild the doubler. I marked and drilled holes in a 3-3/8 by 4 inch plate of 1/8" thick aluminum to mount the passive, full-wave harmonic generator on the side of the microwave brick oscillator. The plate is clamped under the brick side cover. Testing went smoothly with no problems. No tuning is required or even possible. The fundamental feedthrough is about 10 dB below the 2.4 GHz output. No other harmonics are noticeable. I applied a couple of label decals and then sprayed the circuit and enclosure with a protective layer of clear lacquer.

Even with the nearest spurious output frequency being 1.2 GHz away from the desired output, I decided to eliminate, or at least reduce the 1.2 GHz feedthrough. I added a hairpin filter that was at one time available from Mavin. The filter has a 3dB bandwidth of 107 MHz (2.363-2.470 GHz) and a 10db bandwidth of 150 MHz (2.346-2.496 GHz), see: <http://www.fredspinner.com/W0FMS/>.

With the filter in place, the 1.2 GHz signal essentially disappeared. I fabricated an aluminum cover plate for the frequency doubler that was extended to hold the band-

pass filter in place. The result, see the before and after Photo C, looks and works well.

With a -20V power source, the 2.4 GHz marker generator draws 360mA on start-up and the current drain drops to 250mA when the crystal oven temperature stabilizes. I used a Hewlett-Packard 431B power meter with a 478A sensor head and a 10dB attenuator to measure the output power at each stage. The RF output directly from the brick is 40 mW. The total RF output from the frequency doubler is 1.8mW. The fundamental frequency feedthrough is 10dB below the second harmonic and all other harmonics are negligible. Hence, the 2.4 GHz output from the doubler is approximately 1.62mW. The doubling loss is 13.9dB. Typically, a diode frequency doubler has a conversion loss between 12 and 14dB. I was pleased with my result. The 2.4 GHz RF output after the Mavin filter is 0.38mW. The filter loss is 6.3dB, which is comparable to others' measurement of 4.9dB especially because my figure includes cabling and connector losses. The net loss is approximately 20dB. The final result is a strong, crystal controlled, marker generator with no spurious signals – just what I need.

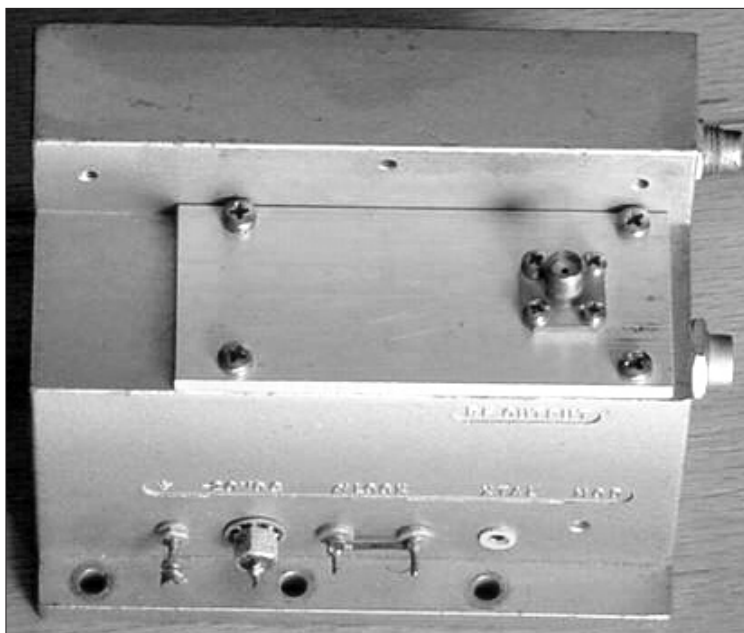


Photo A: Output coupling plate replacing the SRD Multiplier.

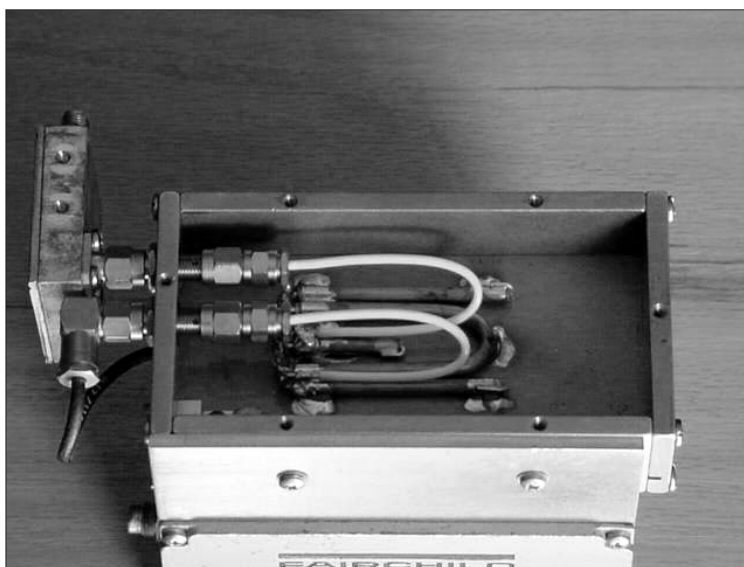


Photo B: Full wave frequency doubler and bandpass filter.

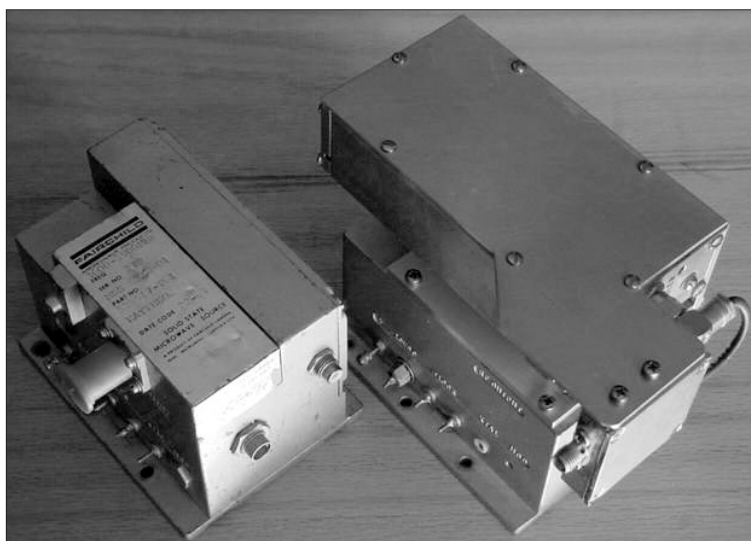


Photo C: Before and after - brick to 2.4 GHz marker generator.

The Courteous Ham's Guide to AO-51, v1.1

Ben Jackson, N1WBV, bbj@innismir.net

with help from

John Marranta Jr., KB2HSH

Charles Reiche, N3CRT

Mark Vande Wetering, KF6KYI

This document was created due to the ever-increasing load on the AO-51 satellite. While an increase in users is always a good thing, the limitations of the FM repeaters on board AO-51 can often cause a situation that is detrimental to all the users of the satellite. This document was created to suggest operating guidelines and discourage behavior that hurts everyone on the satellite.

- Pay attention to the schedule

The AO-51 control team publishes a schedule every month detailing what modes the satellite will be in, what repeaters will be active, and if there are any special events that might be happening on the satellite for a specific period. Read the schedule. Consult it regularly. It can be the difference between you working the satellite or having a frustrating pass because you're transmitting on the wrong frequency.

- Don't transmit if you can't hear it

This is the cardinal rule of satellite operation. AO-51 has a rather strong signal and can be heard on high passes rather easily even with a modest setup. I can sometimes even hear it (albeit faintly) with a simple rubber duck on good passes. AO-51 usually is jammed packed with people when it is VHF Up, UHF Down (V/U) mode over the US. If the schedule says that it's operating in V/U, and you can't hear it, resist the urge to transmit. Sit down, go over your setup, and make sure your ducks are in a row. It's likely something on your end. Remember, there is always another pass.

- Don't throw carriers, whistle, or otherwise jam the bird

This is a bit of a continuation of the previous rule. When looking for the satellite, don't transmit blindly. Again, when the satellite is over the US and in V/U, the satellite will likely be jammed packed. AO-51 can hear much better than it can transmit. There have been stations where the station transmitting has a great signal into the satellite while saying they can barely hear it. If you transmit while the satellite is overhead, it will likely hear you, and you may step on an existing QSO.

- Listen to the downlink - but use headphones!

This is good practice, as you can verify you are "making the trip." It also has benefits, one of which we will discuss later. But, if you do this, use headphones to do it. If you don't, it is possible you'll transmit nothing but feedback, which makes you impossible to understand and gives everyone listening an earful of screechy badness.

- Don't call CQ

Did we mention that AO-51 is crowded? We did? OK, because it is. Due to this, keeping your transmissions short is a win-win situation. It allows more people to use the satellite, and it lessens the chance of you getting stepped on by a spurious transmission. So, going "CQ Satellite, this is November One Whiskey Bravo Victor, CQ!" ties up the satellite and often has people stepping on the transmission as well. Instead, saying "November One Whiskey Bravo Victor" or "November One Whiskey Bravo Victor, listening" or even "November One Whiskey Bravo Victor, Foxtrot November Four One" will keep it quick, and lessen your chances of being doubled.

- If you think you are doubling, stop transmitting!

Speaking of doubling, if you think you are, STOP TRANSMITTING! This is more common when you have the ability to monitor the downlink. Doubling helps no one. Even if you were "first" and someone came on top of you, just let it go. Having two carriers tie up the satellite helps no one, so just be the bigger person and let the other station go first.

- Use Phonetics, most of the time.

Use of standard phonetics is good practice always. Standard phonetics are often burned into ham's brains and can allow quick translation between the word and the letter. While you may have a really cute version of your call based on your pet name from college, using it on the satellite will often require stations to ask you to repeat it. The only exception to this is that if the other station has your call correct, consider giving your call non-phonetically to help with speed.

- Yield to Portable and QRP

Portable and QRP stations are usually just above the noise and often have difficulty making it into the satellite. If you hear someone ID with "Portable" or "QRP" making a call, back off and let them have a turn. Marginal setups often require skill and luck, so help fate along and allow the station running 5W have a chance. However, on the other hand, if you have a hand held, and are clearly not getting a very good signal and the satellite is busy, give others a turn too.

- Know your grid

In VHF, position reports are given by what are known as "grid squares." AMSAT has a nice online converter at <http://www.amsat.org/amsat/toys/gridconv.html>. If you are going to try to work a pass, know the first four characters of your grid square beforehand. Giving your position as a city and state will cause confusion as he or she will be expecting your "grid."

- QSO in progress? Back off!

If someone calls a station, give them a window to have the other station respond. Don't instantly transmit your call again. If the other station responds, wait until they exchange their information before transmitting again.

- In a QSO? Make it quick!

The flip side of this coin is that if you are in a QSO, make it quick as to allow other stations a chance to use the satellite. If a station calls you, jump on it quick so that you're not leaving the satellite idle. Also, AO-51 is very much like a contest when it's crowded, so often the only things exchanged are call sign, grid, and sometime a name or a quick message. Knowing that you are in western Kansas visiting your great aunt may be OK for a ragchew on HF or the local repeater, on the satellite you're just tying it up.

- Don't clobber the bird with watts.

AO-51 can be worked even with a modest setup. Running 50W into a directional antenna may give you more "muscle", it is usually quite unnecessary. Consider leveling

continued on page 14 ...



2008 AMSAT Field Day Competition

Bruce Paige, KK5DO, kk5do@amsat.org

It's that time of year again – summer and Field Day! Each year the American Radio Relay League (ARRL) sponsors Field Day as an emergency preparedness exercise. The event takes place during a 24-hour period on the fourth weekend of June. For 2008 the event takes place during a 27-hour period on the fourth full weekend of June, from 1800 UTC on Saturday June 28, 2008 through 2100 UTC on Sunday June 29, 2008. Those who set up prior to 1800 UTC on June 28 can operate only 24 hours. The Radio Amateur Satellite Corporation (AMSAT) promotes its own version of Field Day for operation via the amateur satellites, held concurrently with the ARRL event.

If you are considering ONLY the FM voice satellites like AMSAT-OSCAR 16, AMRAD-OSCAR-27, SaudiSat-Oscar-50, or AMSAT-OSCAR-51 for your AMSAT Field Day focus, don't, unless you are simply hoping to make one contact for the ARRL rules bonus points. The congestion on FM LEO satellites was so intense in prior years that we must continue to limit their use to one-QSO-per-FM-satellite. This includes the International Space Station. You will be allowed one QSO if the ISS is operating Voice. You will also be allowed one digital QSO with the ISS or any other digital, non-store-and-forward, packet satellite (if operational).

The format for the message exchange on the ISS or other digital packet satellite is an unproto packet to the other station (3-way exchange required) with all the same information as normally exchanged for ARRL Field Day,

e.g.:

W6NWG de KK5DO 2A STX

KK5DO de W6NWG QSL 5A SDG

W6NWG de KK5DO QSL

If you have worked the satellites on Field Day in recent years, you may have noticed a lot of good contacts can be made on some of the less-populated, low-earth-orbit satellites like Fuji-OSCAR 29 (may or may not be operational) and AMSAT-OSCAR 7. During Field Day the transponders come alive like 20 meters on a weekend. The good news is that the transponders on these satellites will support multiple simultaneous contacts. The bad news is that you can't use FM, just low duty-cycle modes like SSB and CW.

The 2008 AMSAT Field Day Rules

The AMSAT Field Day 2008 event is open to all Amateur Radio operators. Amateurs are to use the exchange as specified in ARRL rules for Field Day. The AMSAT competition is to encourage the use of all amateur satellites, both analog and digital. Note that no points will be credited for any contacts beyond the ONE allowed via each single-channel FM satellite. Operators are encouraged not to make any extra contacts via these satellites (Ex: AO-27 & SO-50). CW contacts and digital contacts are worth three points as outlined below.

1. Analog Transponders

ARRL rules apply, except:

- Each phone, CW and digital segment ON EACH SATELLITE TRANSPONDER is considered to be a separate band.
- CW and digital (RTTY, PSK-31, etc.) contacts count THREE points each.
- Stations are limited to one (1) completed QSO on any single channel FM satellite. If AO-51 has the V/U and L/S modes turned on, one contact each is allowed. If the PBBS is on - see Pacsats below, ISS (1 phone and 1 digital), Contacts with the ISS crew will count for one contact if they are active. PCSat (I, II, etc.) (1 digital),
- The use of more than one transmitter at the same time on a single satellite transponder is prohibited.

2. Digital Transponders

For the Pacsats (GO-32, AO-51) or 'Store and Forward' hamsats, each satellite is considered a separate band. Do not post "CQ" messages. Simply upload ONE greeting message to each satellite and download as many greeting messages as possible from each satellite. The subject of the uploaded file should be posted as Field Day Greetings, addressed to ALL. The purpose of this portion of the competition is to demonstrate digital satellite communications to other Field Day participants and observers. Do not reply to the Field Day Greetings addressed to ALL.

The following uploads and downloads count as three-point digital contacts.

- (a) Upload of a satellite Field Day Greetings file (one per satellite).
- (b) Download of Satellite Field Day Greetings files posted by other stations. Downloads

of non-Field Day files or messages not addressed to ALL are not to be counted for the event. Save DIR listings and message files for later "proof of contact."

Please note AMSAT uploaded messages do not count for QSO points under the ARRL rules.

Satellite digipeat QSO's and APRS short-message contacts are worth three points each, but must be complete verified two-way exchanges. Remember, only one digipeat contact is allowed for the ISS and other satellites in this mode.

The use of terrestrial gateway stations or Internet gateways (i.e. EchoLink, IRLP, etc.) to uplink/downlink is not allowed.

Sample Satellite Field Day Greetings File:

Greetings from W5MSQ Field Day Satellite station near Katy, Texas, EL-29, with 20 participants, operating class 2A, in the AMSAT-Houston group with the Houston Amateur Television Society and the Houston QRP club. All the best and 73!

Note that the message stated the call, name of the group, operating class, where they were located (the grid square would be helpful) and how many operators were in attendance.

3. Operating Class

Stations operating portable and using emergency power (as per ARRL Field Day rules) are in a separate operating class from those at home connected to commercial power. On the report form simply check off Emergency or Commercial for the Power Source and be sure to specify your ARRL operating class (2A, 1C, etc.).

And Finally ...

The Satellite Summary Sheet should be used for submission of the AMSAT Field Day competition and be received by KK5DO (e-mail or postal mail) by 11:59 P.M. CDT, Monday, July 14, 2008. The preferred method for submitting your log is via e-mail to kk5do@amsat.org or kk5do@arrl.net.

You may also use the postal service but give plenty of time for your results to arrive by the submission date. Add photographs or other interesting information so that can be used an article for *The AMSAT Journal*.

You will receive an e-mail back (within one or two days) from me when I receive your



email submission. If you do not receive a confirmation message, then I have not received your submission. Try sending it again or send it to my other e-mail address.

If mailing your submission, the address is:

Bruce Paige, KK5DO

Director of Awards and Contests

PO Box 310

Alief, TX 77411-0310

Certificates will be awarded to the first-place emergency power/portable station at the AMSAT General Meeting and Space Symposium in October, 2008. Certificates will also be awarded to the second and third place portable/emergency operation in addition to the first-place home station running on emergency power. Stations submitting high, award-winning scores will be requested to send in dupe sheets for analog contacts and message listings for digital downloads.

You may have multiple rig difficulties, antenna failures, computer glitches, generator disasters, tropical storms and there may even be satellite problems, but the goal is to test your ability to operate in an emergency situation. Try different gear. Demonstrate satellite operations to hams that don't even know the hamsats exist. Test your equipment. Avoid making more than ONE contact via the FM-only voice hamsats or the ISS, and enjoy the event! 🌐

This form is designed to allow for easy editing in a Word Processor.

AMSAT Satellite Summary Sheet - 2008

Satellite and number of Voice QSO's

AO-27 1 (example)

Satellite and number of CW/RTTY/PSK31 etc QSO's

AO-7 5 (example)

Satellite and Up/Downloads

UO-11 3 (example)

Score Calculation

Total Voice QSO's x 1 =

Total CW/RTTY/PSK31 QSO's x 3 =

Total Up/Downloads x 3 =

Grand Total =

Please provide the following information:

Your Field Day Callsign:

Your Group Name:

ARRL Field Day Classification:

ARRL Section:

Power Source (Select 1)

Emergency

Commercial

Your name and home call:

Home address

Any Comments



the playing field for less powerful stations by dialing down your power.

- Don't hog the satellite.

If you are one of the stations making a good signal into the satellite, the temptation is to work every station possible. While it is easy to do this in courteous fashion, let other stations have a chance as well. A good rule of thumb is to go after 2-3 QSOs then back off. Remember, this might not mean 2-3 *total* QSOs, as if other stations call you, respond.

- Do encourage good behavior

If you hear stations acting in a courteous manner, be sure to try and work them. If you hear other stations acting in a non-courteous manner, don't work them. Also, feel free to message people "offline" via e-mail if you hear them working in a courteous manner but didn't have anyone work them. A little thank you goes a long way.

- Don't scold bad behavior on air

Scolding bad behavior on air may seem gratifying, but tying up the satellite with your message doesn't help the situation at all. Instead, contact the stations "offline" and offer help. Sometimes the station will be receptive, sometimes they won't.

- Use your judgment

As always, these are guidelines. Sometimes AO-51 is wide open or only has a handful of stations. You may need to transmit without "hearing" somebody. If it's rather empty, take advantage of it to have a quick conversation over satellite. Just leave gaps for other stations to join in. These guidelines are only suggestions from a few amateurs who love AO-51 and just want to see it used to its maximum potential.

Of course, the most important rule of courteous AO-51 operation is to have fun! Hopefully, the more people follow these guidelines the more chances you will have to test your homebrew antenna, your new low wattage setup, and grab new grid squares! AO-51 is an amazing asset to the amateur community and the more people use it in a courteous manner, the better it is for everyone.

Special Thanks to KB2HSH, N3CRT, KF6KYI, K9JKM, VA3DB and the rest of the crew on #amsat channel on irc.dishnuts.net. ☺

Support AMSAT

New Version!

AMSAT is the North American distributor of **SatPC32**, a tracking program designed for ham satellite applications. For Windows 95, 98, NT, ME, 2000, XP, Vista.

Version 12.7 now supports Labjack U12/U3/Piggyback, LVBTracker and W0LMD rotor controllers and Doppler tuning for Yaesu FT-817/857/897.

Version 12.7 Features:

- Select 2D/3D map with a single mouse click
- Select Political/Physical map with a single mouse click
- AOS voice announcement
- Countdown program displays next AOS of your favorite satellites
- Automatic Internet download of Keplerian elements.
- Graphical tracking on a world map with two selectable Zoom factors.
- One-click satellite switching using 12 "letter" buttons.
- Automatic rotor control support for: LVBTracker, Kansas City Tracker/Tuner, FODtrack, Uni_Trac, SatEL, Labjack U12/U3/Piggyback, W0LMD Mini/Junior/Senior Trackers, Yaesu GS-232, ARS from EA4TX, EGIS rotors, IF-100, RIF-PC, AMSAT-DL interface, WinRotor32, HalloRotor, and WiSP DDE clients.
- Doppler tuning with on-screen frequency displays. Radio models supported:
Yaesu FT-847, FT-736R, FT-817, FT-857, FT-897
ICOM IC-820H, IC-821H, IC-910H and other ICOM radios
Kenwood TS-790 and TS-2000
DDE client programs
- "Transparent" VFO-knob tuning in addition to keyboard and mouse tuning.
- "Virtual" VFO tracking for half-duplex transceivers FT-817, FT-857, FT-897.
- Includes a special version for ISS split-frequency operation.
- Controls subaudible tone on FT-847, FT-736R, FT-817/857/897, TS790A and IC-910H.
- Includes a non-graphical version and programs that output lists to the screen, printer, or a file.
- Interfaces with WiSP, with user-defined satellite switching priority.
- Includes a separate program for tracking the Sun and Moon.

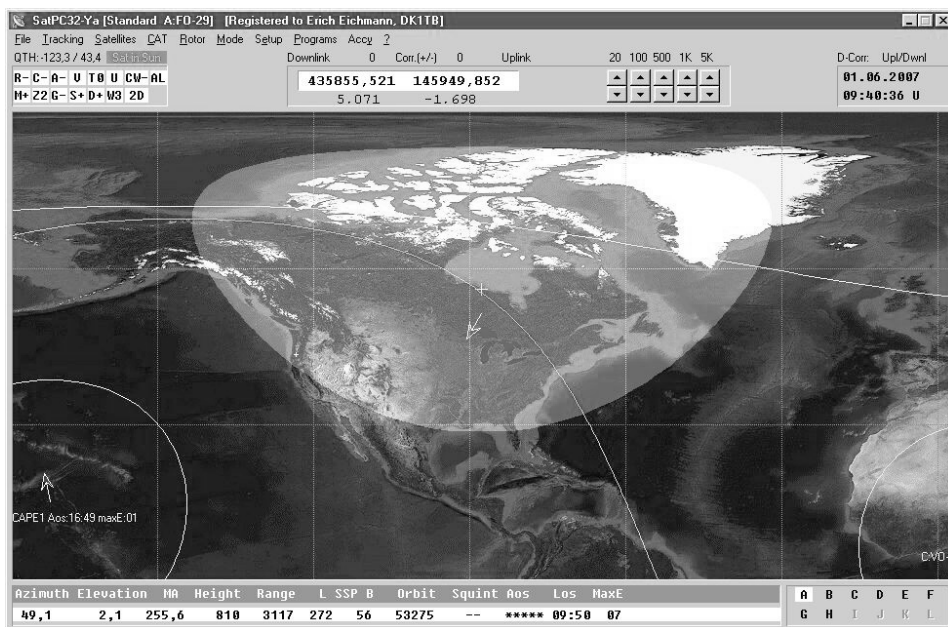
Price is \$45 for AMSAT members, \$50 for non-members, on CD-ROM.

A demo version may be downloaded from <http://www.dk1tb.de/indexeng.htm>

A registration password for the demo version is \$40 (members), \$45 (non-members).

Order by calling 1-888-322-6728.

The author DK1TB donated SatPC32 to AMSAT. All proceeds support AMSAT.





LVB Tracker Box

- Reasonably priced and all profits go to AMSAT
- USB or serial interface
- Ethernet interface capable
- Open software
- Open architecture
- Built-in rotor interface cable with DIN connector
- Power supplied via the rotor controller cable
- Bi-directional interface allows the unit to read the rotor position
- LCD position readout
- Front panel manual control
- Self-programmable, allows for easy software upgrades
- Supported by the major tracking programs
- Uses GS-232A or Easycomm I/II protocols

Contact Martha at the AMSAT office 301-589-6062 to order.

The complete units will be built in groups, so get your orders in early.

Units will be shipped as they become available.

- 1) Bare board - \$20 + S&H - no parts kits available
- 2) Populated board, serial interface - \$100 + S&H - no kit with USB unit, rotor cable and LCD available, we do have a parts list with recommended part numbers and sources.
- 3) Custom Ten-Tec Enclosure powder coat, silk-screened, drilled/punched - \$50 + S&H
- 4) Complete unit - board, USB output, rotor cable, LCD, enclosure, serial chip - \$200 + S&H **our most popular

Documentation for the LVB Tracker can be found at: <http://www.LVBTracker.com>

Boards and complete units may be ordered from the AMSAT office at 301-589-6062 or from martha @ amsat.org

The Classroom Satellite

Used by NASA, the U.S. Air Force Academy, and institutions around the world to give students and working professionals hands-on experience with satellites.

"I've been controlling satellites with reaction wheels for 20 years - now I really understand how they work!" - NASA Engineer

Find out more at <http://www.EyasSat.com> !

YOUR SATELLITE ANTENNA SOURCE

NEW! Ultra-gain!

436CP42-U/G
42 elements,
18' 10" tapered boom
(pair with 2MCP22)

436CP30
30 elements,
9' 9" boom
(pair with 2MCP14)

2MCP14
14 elements'
10' 6" boom

2MCP22
22 elements,
18' 6" boom

EB-144 & EB-432
Eggbeaters,
see 9/93 QST

- Stacking frames
- AZ & EL positioners
- Fiberglass crossbooms
- Power Dividers
- Phasing harnesses

M² 4402 N. Selland
Fresno, CA 93722
(559) 432-8873 FAX: 432-3059



The Orbital Classroom, Column #13

National Science Education Standards

© 2008 by Prof. H. Paul Shuch, N6TX

AMSAT Director of Education



The Orbital Classroom

You've probably read in recent issues of *The AMSAT Journal* about plans to develop an AMSAT Teacher's Institute, to provide educators with the background necessary to incorporate satellites into their curricula. This column summarizes the standards with which such an effort must comply.

The fundamental law governing education throughout the US is No Child Left Behind (NCLB, which by educators is pronounced "nickelbee".) NCLB mandates achievement testing for all students, in the areas of reading and mathematics, and ties federal funding for school districts not to test results *per se*, but rather to *improvement* in test results from year to year. In other words, the goal of NCLB is to show annual progress. Most school districts set achieving NCLB guidelines as their highest priority. There are at present no accepted standardized achievement tests in the sciences, hence no NCLB science standards. Most educators with whom I've spoken expect NCLB science standards eventually to be established, but this is not likely to happen for a decade or more. Hence, professional development in the sciences is not currently a priority for educators or school districts.

National Science Education Standards do exist, but compliance is strictly voluntary on the part of individual school districts. These standards were developed jointly by the National Science Teacher's Association (NSTA), American Academy for the Advancement of Science (AAAS), National Science Resources Center (NSRC), National Research Council (NRC) National Science Foundation (NSF) and several smaller organizations, working through the National committee on Science Education Standards and Assessment (NCSESA). The standards emphasize benchmarks for science literacy, and were distributed in draft form in 1994 to 18,000 individuals and 250 groups.

The goals for school science that underlie the National Science Education Standards are to educate students who are able to:

- Experience the richness and excitement of knowing about and understanding the natural world;
- Use appropriate scientific processes

and principles in making personal decisions;

- Engage intelligently in public discourse and debate about matters of scientific and technological concern; and
- Increase their economic productivity through the use of the knowledge, understanding, and skills of the scientifically literate person in their careers.

Logically, any AMSAT educational endeavor should show compliance with these four bullets.

The National Science Education Standards address continuing education and professional development requirements for teachers. The standards address various professional development areas, which can be summarized as: learning science, learning to teach science, and learning to learn. Specific standards in these areas are excerpted below.

Professional Development Standard A

Professional development for teachers of science requires learning essential science content through the perspectives and methods of inquiry. Science learning experiences for teachers must:

- Involve teachers in actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings consistent with currently accepted scientific understanding.
- Address issues, events, problems, or topics significant in science and of interest to participants.
- Introduce teachers to scientific literature, media and technological resources that expand their science knowledge and their ability to access further knowledge.
- Build on the teacher's current science understanding, ability, and attitudes.
- Incorporate ongoing reflection on the process and outcomes of understanding science through inquiry.
- Encourage and support teachers in efforts to collaborate.

To meet the Standards, all teachers of science

must have a strong, broad base of scientific knowledge extensive enough for them to:

- Understand the nature of scientific inquiry, its central role in science and how to use the skills and processes of scientific inquiry.
- Understand the fundamental facts and concepts in major science disciplines.
- Be able to make conceptual connections within and across science disciplines, as well as to mathematics, technology and other school subjects.
- Use scientific understanding and ability when dealing with personal and societal issues.

Professional Development Standard B:

Professional development for teachers of science requires integrating knowledge of science, learning, pedagogy and students; it also requires applying that knowledge to science teaching. Learning experiences for teachers of science must:

- Connect and integrate all pertinent aspects of science and science education.
- Occur in a variety of places where effective science teaching can be illustrated and modeled, permitting teachers to struggle with real situations and expand their knowledge and skills in appropriate contexts.
- Address teachers' needs as learners and build on their current knowledge of science content, teaching, and learning.
- Use inquiry, reflection, interpretation of research, modeling, and guided practice to build understanding and skill in science teaching.

Professional Development Standard C:

Professional development for teachers of science requires building understanding and ability for lifelong learning. Professional development activities must:

- Provide regular, frequent opportunities for individual and collegial examination and reflection on classroom and institutional practice.
- Provide opportunities for teachers to receive feedback about their teaching



and to understand, analyze, and apply that feedback to improve their practice.

- Provide opportunities for teachers to learn and use various tools and techniques for self-reflection and collegial reflection, such as peer coaching, portfolios and journals.
- Support the sharing of teacher expertise by preparing and using mentors, teacher advisers, coaches, lead teachers and resource teachers to provide professional development opportunities.
- Provide opportunities to know and have access to existing research and experiential knowledge.
- Provide opportunities to learn and use the skills of research to generate new knowledge about science and the teaching and learning of science.

Professional Development Standard D:
Professional development programs for

teachers of science must be coherent and integrated. Quality preservice and inservice programs are characterized by:

- Clear, shared goals based on a vision of science learning, teaching, and teacher development congruent with the National Science Education Standards.
- Integration and coordination of the program components so that understanding and ability can be built over time, reinforced continuously, and practiced in a variety of situations.
- Options that recognize the developmental nature of teacher professional growth and individual and group interests, as well as the needs of teachers who have varying degrees of experience, professional expertise, and proficiency.
- Collaboration among the people involved in programs, including teachers, teacher educators, teacher

unions, scientists, administrators, policy makers, members of professional and scientific organizations, parents and business people, with clear respect for the perspectives and expertise of each.

- Recognition of the history, culture and organization of the school environment.
- Continuous program assessment that captures the perspectives of all those involved, uses a variety of strategies, focuses on the process and effects of the program, and feeds directly into program improvement and evaluation.

If AMSAT Teacher's Institutes are to be a credible professional development avenue for educators, we cannot simply teach satellites, or let the teachers play in the lab. We have to show very specifically how our program addresses these individual bullets. The next Orbital Classroom column will discuss how AMSAT can best meet these standards. ☺

Apogee View continued from page 3 ...

the ground, giving new meaning to the phrase the "ultimate DX-pedition". He was instrumental in guiding the development of a simple ham radio system that could be used in multiple configurations on the Space Shuttle. As a result, his first flight on STS-35 ushered in the "frequent flyer" era of the Shuttle Amateur Radio Experiment (SAREX) payload. He was the first ham in space to operate packet radio. And his flight pioneered the telebridge ground station concept to enable more schools to talk to Shuttle crewmembers despite time and orbit constraints. In his two shuttle flights, he inspired countless students to seek technical careers and he created memories at the schools and communities that will never be forgotten.

Ron's love for the Amateur Radio hobby and his love of inspiring students continued well beyond his two Shuttle flights. During

the formation of the Amateur Radio on the International Space Station (ARISS) program, Ron was a tremendous resource to the newly forming international team. I know of many instances where Ron's wisdom and sage advice was instrumental in helping our international team resolve issues when we reached critical technical or political roadblocks. And he was a key volunteer in the development of the ham radio hardware systems that are now on-board ISS. The ARISS team is deeply indebted to WA4SIR for his leadership, technical advice and tremendous vision.

Ron worked hand-in-hand with the students at the Naval Academy and Embry-Riddle Aeronautical University on the development of their student satellites. He helped develop Radio Jove, a student educational project to listen to the radio signals emanating from Jupiter. And he spoke at numerous schools

over the years, inspiring them to pursue careers in science, math and technology.

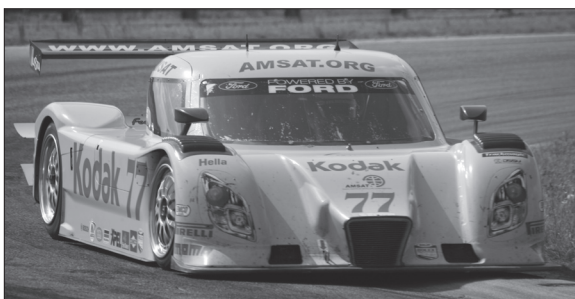
I feel blessed to have had Ron as a friend, colleague, ham buddy and mentor. He gave so much, cheerfully, to our collective hobby and was always there with the right answer no matter the topic. I will miss him dearly.

In an effort to continue Ron's tireless work to inspire the next generation, the Parise family has set up a scholarship fund in Ron's honor. The scholarship is for students pursuing technical degrees at Youngtown State University, where Ron received his Bachelors of Science degree. In lieu of flowers, those interested are welcome to send donations to the Dr. Ronald A. Parise Scholarship Fund, Youngstown State University, One University Plaza, Youngstown, Ohio 44555.

On behalf of AMSAT and the ARISS International team, I would like to extend our collective condolences to the Parise family and to all Ron's friends. Our thoughts and prayers are with you.

And to Ron Parise, WA4SIR, SK: Our sincerest 73's and 88's—may your exploration spirit live on in us all!!

Frank H. Bauer, KA3HDO
AMSAT-NA V.P. for Human Spaceflight Programs
Chairman, ARISS International ☺



AMSAT's name was prominently displayed on the Doran Racing #77 Ford Dallara during the Rolex Daytona Prototype Bosch Engineering 250 at Virginia International Raceway in Alton, VA on April 26, 2008. The car started seventh on the grid and was driven by Brad Jaeger, the son of AMSAT member Jim Jaeger, K8RQ, and by professional driver Memo Gidley. Attending from AMSAT were Rick Hambly, W2GPS, President, Tom Clark, K3IO, Board Member, and Gould Smith, WA4SXM, Vice President User Services. This picture is published with permission by F&S Enterprises.



AMSAT[®] President's Club!

Join Now!

Contribute to **AMSAT[®]** directly through easy, automatic charges to your credit card.
Donations may be USA tax deductible. (Check with your tax advisor.)

Titanium Donors contribute at least US \$400 per month.

Every **Titanium Donor** receives gifts of:

☐ \$400 / month

- ✓ Everything at the Platinum Donor Level, PLUS:
- ✓ A very special, *hand crafted*, AMSAT President's Club Donor's pin.

☐ \$4800 one time

Platinum Donors contribute at least US \$200 per month.

Every **Platinum Donor** receives gifts of:

☐ \$200 / month

- ✓ Everything at the Gold Donor Level, PLUS:
- ✓ A very special, *hand crafted*, AMSAT President's Club Donor's pin.

☐ \$2400 one time

Gold Donors contribute at least US \$100 per month.

Every **Gold Donor** receives gifts of:

☐ \$100 / month

- ✓ Everything at the Silver Donor Level, PLUS:
- ✓ A personal invitation to the AMSAT Dayton dinner (free).

☐ \$1200 one time

Silver Donors contribute at least US \$50 per month.

Every **Silver Donor** receives gifts of:

☐ \$50 / month

- ✓ Everything at the Bronze Donor Level, PLUS:
- ✓ A personal invitation to a reception with the AMSAT Directors, Officers and project designers and builders (free).
- ✓ Annual endorsement sticker after each year of donation.

☐ \$600 one time

Bronze Donors contribute at least US \$25 per month.

Every **Bronze Donor** receives gifts of:

☐ \$25 / month

- ✓ A unique "AMSAT President's Club" certificate.
- ✓ A specially designed AMSAT President's Club Donor pin.

☐ \$300 one time

Core Donors contribute at least US \$10 per month.

Every **Core Donor** receives gifts of:

☐ \$10 / month

- ✓ A specially designed AMSAT President's Club Donor pin.

☐ \$120 one time

Choose where your contribution should go:

☐ AO-Echo ☐ AO-Eagle ☐ ARISS ☐ Future Projects ☐ General Fund

☐ RENEW my President's Club AUTOMATICALLY every year!

☐ I prefer to make my donation in one yearly payment of \$ ____.

(Credit card only, please.)

THANK YOU!



Successful AMSAT Activities at 2008

Greater Houston Hamfest

by Allen F. Mattis, N5AFV, n5afv@amsat.org

AMSAT was well represented at the Greater Houston Hamfest (GHH) held March 1, 2008 at the Fort Bend County Fairgrounds in Rosenberg, Texas. The GHH is the fastest growing hamfest in Texas and this year the GHH hosted the American Radio Relay League (ARRL) South Texas Section Convention and the Texas VHF-FM Society General Winter Meeting. Coy Day, N5OK, the ARRL West Gulf Division director was the featured speaker, and West Gulf Division vice director Dr. David Woolweaver, K5RAV, also attended. The GHH had all of the usual hamfest activities including tables for vendors and individuals, a tailgate area, Amateur Radio related exhibits, VE testing sessions and QSL card checking for the ARRL DXCC and VUCC award programs.

Bruce Paige, KK5DO, AMSAT Director of Contests and Awards, and Marty Smith, WD5DZC, ably manned the AMSAT booth. Will Thomas, N5ESA, conducted a very successful satellite demonstration during a western pass of AO-51. George Carr, WA5KBH, and Allen Mattis, N5AFV, operated receiving stations within the crowd of 65 onlookers so that everyone could hear the bird. Immediately after the satellite pass, Allen Mattis, N5AFV, presented a talk entitled "Working the OSCAR Satellites with Simple Equipment" that was attended by 25 people. George, WA5KBH, and Will, N5ESA, assisted at the presentation by helping answer questions.

The Brazos Valley Amateur Radio Club (BVARC), organizer of the hamfest, fully supported the AMSAT activities by giving away a Kenwood TH-D7A HT, Arrow antenna and duplexer as the second prize at the hamfest. The Greater Houston Hamfest Steering Committee received many favorable comments from attendees regarding the AMSAT activities. 📡



Figure 4: View of Greater Houston Hamfest main floor from AMSAT booth.



Figure 1: Entrance to the 2008 Greater Houston Hamfest.



Figure 2: Bruce Paige, KK5DO, AMSAT Director of Contests and Awards and Marty Smith, WD5DZC, at the AMSAT booth.



Figure 3: ARRL West Gulf Division director Coy Day, N5OK, (left) and West Gulf Division vice director Dr. David Woolweaver, K5RAV, (right) visit with Allen Mattis, N5AFV, AMSAT Area Coordinator, at the AMSAT Booth.



Figure 5: George Carr, WA5KBH, at satellite demonstration with Will Thomas, N5ESA, in left background (Photograph provided by Doug Holley, KE5SR).



Figure 6: George Carr, WA5KBH, answering questions at AMSAT technical presentation.

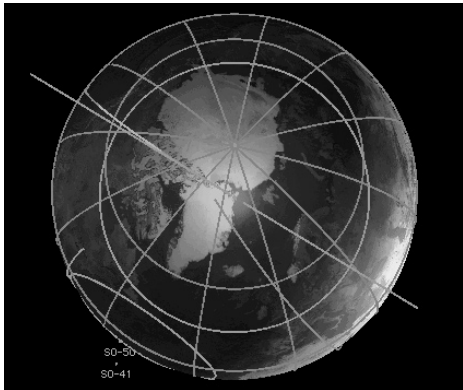


AMSAT now offers a 2GB Flash Drive with the AMSAT logo. Save your stuff and show your support for AMSAT. \$30 + Shipping



MacDopplerPRO X

The premier Satellite tracking and station automation application for the Macintosh - OS 9 & OS X



MacDopplerPRO X gives you a seat right in the heart of the Operations & Command Centre for every satellite in orbit. In fact up to thirty two front row seats at the same time, providing any level of station automation you need from assisted Doppler Tuning and Antenna Pointing right on up to fully automated Satellite Gateway !

It will calculate the position and relative velocity of the satellite you are tracking and automatically adjust the Doppler shift on both transmit and receive as well as pointing your antennas with predictive dead spot crossing so that a pass is never interrupted by the beam heading passing a dead spot.

MacDopplerPRO X provides separate windows for the map (2D or 3D), the radio controls, and the sorted table of upcoming satellite passes. A Horizon window graphs upcoming passes as a function of elevation over time for status at a glance.

Now available at a special member discount price from AMSAT !

martha@amsat.org
850 Sligo Ave.,
Silver Spring MD,
20910-4703 USA.
(301) 589-6062, (301) 608-3410 (Fax)

Dog Park Software Ltd.
www.dogparksoftware.com

Do you still use manual tuning to remove Doppler changes? Why not automate?

Uni-Trac 2000 will automatically tune your Receiver (and Transmitter) to compensate Doppler frequency changes. Uni-Trac will also STEER your Antenna !

Uni-Trac 2000, including Interface Cable \$280.00
FOB Concord, Mass. 01742, USA.



Spectrum International, Inc.,
P.O. Box 1084,
Concord, Mass. 01742, USA.
Tel: (978) 263-2145
Fax: (978) 263-7008

SSB ELECTRONIC USA

PHASE 3D Equipment Headquarters

SSB Electronic USA features world class VHF - UHF - SHF equipment. The latest gear from: SSB Electronic, Kuhne Electronic - DB6NT, M2 Antennas, Beko Electronic, EME, Procomm, AIRCOM PLUS, AIRLINK, ECOFLEX and WINRADIO is available.

- Mast Mounted Preamplifiers 144 - 2400 MHz.
- Ultra Low Noise LNA's 50.0 MHz. 24.0 GHz.
- Transverters 50 MHz. - 24.0 GHz.
- Antennas - Rotors
- Downconverters and TX Upconverters for all P3D frequencies
- Mode "S" Downconverters
- Mode "L" TX Upconverters
- Linear Amplifiers 50 MHz. - 24.0 GHz.
- Ultra Low Loss Coaxial Cable
- Transverter Kits 1.2, 2.4, 5.7 & 10 GHz.
- Parabolic Dishes

So What's New ?

BEKO Electronic: 144 MHz. - 1296 MHz. Linear Amplifiers 100 Watts - 1200 Watts

DB6NT Electronic: MKU 24 OSCAR Mode "S" Downconverter IF 144 or 432 MHz.
MKU 10 OSCAR 10.451 GHz. Down Converter
MKU 24 G2 OSCAR 2.4 GHz. Transverter 1 Watt
MKU 57 OTX 5.6 GHz. OSCAR TX Upconverter *plus more.....*

ECOFLEX - LLC Super Flexible Low Loss Coaxial Cable

SSB Electronic: UEK-3000SAT Mode "S" Downconverter IF 144 or 432 MHz.
UTM-1200 DLX Mast mounted 1269 MHz. 15 Watt TX Upconverter
UTM-1200-1 1269 MHz. 1 Watt TX Upconverter
SP-2000 & SP-7000 Heli-Filtered Mast-Mounted Preamps *plus more.....*



SSB
Electronic USA

For complete specifications and prices, please visit our WEB SITE: www.ssbusa.com

Phone 570-868-5643

New Hours: MTWTFSS
9:00 AM - 11:00 PM

124 Cherrywood Dr.
Mountaintop, PA 18707



Remembering Sir Arthur C. Clarke

by H. Paul Shuch, N6TX, n6tx@amsat.org, AMSAT LM-167
Executive Director Emeritus, The SETI League, Inc.

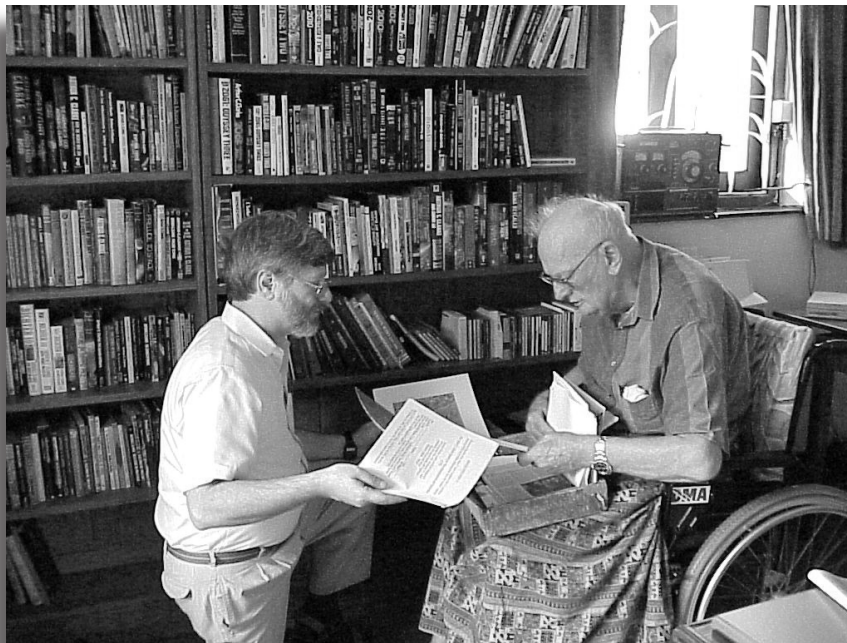
The official obituaries have already been written, most eloquently, and I'm sure you've read them. This is a personal remembrance of Arthur Charles Clarke, science fiction author extraordinaire, advisor to The SETI League, life member of AMSAT, and the world's second greatest communications engineer, who passed away on 18 March 2008, at the age of 90, of complications arising from post-polio syndrome.

Although Clarke has had a direct influence on my whole career (whose hasn't he influenced?), and we had corresponded from time to time, I did not actually meet him in the flesh until January of 2000. It was a memorable meeting (more about which later). Certainly the first Clarke SF novels I read (in high school) included *Childhood's End* and *Prelude to Space*. But it was his brief article 'Extraterrestrial Relays,' in the monthly radio journal *Wireless World* that had its most profound early impact on me.

In 1961, I was a high school student, and a radio ham and the youngster sitting in the back of the room at Project OSCAR meetings, watching my mentors design and build the world's first non-government communications satellite. I remember thinking 'this is what I want to be when I grow up.' We had all read Clarke's seminal article, and (although OSCAR 1 was a low-orbiter) were already thinking about the geosynchronous orbit that he 'invented' back in 1945.

Fast forward to the early 1970s. I had become an aerospace engineer, and was running a small Silicon Valley microwave company, developing receivers for the first geosynchronous earth imaging and communications satellites. I had a small (16 foot - gigantic by today's standards) satellite TV dish in my back yard, and read in *Coop's Satellite Digest* that Clarke himself had a similar dish perched on the balcony of his Colombo residence.

That Clarke lived in Sri Lanka bore a certain technological irony. Because the Earth's center of mass is not at its geographical center (ours is a lumpy planet), even perfectly circular satellite orbits tend to decay over time. From the Clarke Belt, if active station keeping is disabled (or if the satellites run out of the hydrazine fuel burned by their thrusters), the birds tend to drift to the 'low' point in their orbit, a stable resting point over the Indian Ocean. This satellite graveyard was well in view of Arthur's five-meter dish, so I like to think that the dormant geosats were all going home to papa.



In 1979 (by now an engineering professor), I chanced to be in Hawaii, touring the Comsat telemetry, tracking and control (TT&C) station on the North end of Oahu. My host showed me a brief PR film called "Pathways to the World," narrated by none other than ACC. There was a scene showing him standing under his dish, and I thought this would be a great thing to show my students. I asked the Comsat people how I might obtain a print of the film. "Do you have access to an Intelsat terminal?" I was asked. I did indeed (my old homebrew 16 foot dish and C-band receiver). I was given a satellite name, and a transponder number and a time about a week hence. When I arrived home on the Mainland I aimed my dish and tuned my receiver appropriately, and videotaped "Pathways to the World." How's that for appropriate use

of Clarke's technology?

I've since shown that tape to a couple of thousand students, and still cherish it in my video collection. Following the US Congress canceling the NASA SETI program in 1993, several organizations (including the nonprofit, membership-supported SETI League) emerged to fill the void. I was tapped as The SETI League's Executive Director, and one of my first tasks was to recruit luminaries to serve on our advisory board. Arthur accepted graciously, without hesitation. I enjoyed our rich e-mail correspondence these past several years, touching sometimes on SETI matters, sometimes on communications technology and science and sometimes on science fiction. When I went on lecture tour to India in 2000, Sir Arthur kindly invited me to take a side-trip to Colombo, and pay him a visit.

Arriving at the Galle Face Hotel in Colombo, I saw a familiar face in the lobby -- Arthur's brother Fred, whom I had met in the UK a few years prior. Not only did I not know we were staying in the same hotel; I had no idea Fred was in Sri Lanka! That's how small a world we inhabit, and Arthur helped to make it so. Fred's wife Babs had died just two months prior, and he came to visit his brother, and to mourn. Fred and I stayed up most of the night together, sharing songs and poetry and reminiscing about this elegant woman who dazzled me the one time I had met her.

Next day, it was off to Arthur's home (Fred and I together.) When questioned by the hotel concierge earlier as to my business in Colombo (there was a war on, so they asked such questions), I had simply said I was there to visit a friend. Now, as I hired a car and gave that same concierge the address, his eyes widened in a mixture of recognition, surprise and respect. It seems Arthur's house is well known in Colombo!

You may recall that when Isaac Asimov died

a few years back, Clarke eulogized him as 'the world's second-greatest science fiction writer.' That gave me an idea.

Visiting Arthur in his home, I brought the customary gift. Not the traditional bottle of wine, since I no longer lived in California; instead, I wrote the song 'Extraterrestrial Relays', brought along my guitar, and had a chance to sing it to Arthur, his brother and his staff. Arthur was delighted, and asked for a copy. I was prepared, and made him a formal presentation of the original. The sheet music is inscribed "to Sir Arthur C. Clarke, the world's second greatest communications engineer." I heard later that Arthur had framed that page and placed it on the wall in the room of his house, which he wryly called his "ego chamber."

Arthur once told me that he would gladly lend his name and support to our SETI League efforts, and that I could feel free to ask him for anything -- except money. I

respected that request, figuring that his name on the masthead was worth far more than millions in the bank. But, on my one visit to Colombo, he gave me a cheque anyway. And that's a story in itself:

When Clarke invented the geostationary communications satellite (OK, so some will say that Tsiolkovskii *really* invented it; Clarke merely refined and published it), he coined the contraction ComSat, for Communications Satellite. He contributed the name into the public domain, never expecting such technology to emerge within his lifetime. Years later, when the Communications Satellite Corporation was formed, they adopted the trademark Comsat. But their leaders knew where the term really came from, and, though under no legal obligation to do so, wanted to make a token payment to Clarke, in gratitude. So, they gave him one share of Comsat common stock.

Over the years, with stock splits and dividend reinvestments, that one share had multiplied to several, and Clarke began to receive small cheques in the mail from Comsat from time to time. I was in his house when one of those cheques arrived, and just happened to be talking to Arthur while he was going through the mail. He promptly handed over to me a dividend cheque from Comsat, saying "here -- for The SETI League."

Only, I never cashed that cheque. It's framed now, and hanging on my wall, and some poor Comsat accountant is probably wondering to this day why their accounts show a discrepancy of \$4.75.

Now, whenever I look at that cheque, I will fondly remember Sir Arthur Charles Clarke, the world's second greatest communications engineer. Next time I see Fred Clarke, it will, sad to say, again be to mourn. ☹



ARRL and TAPR Digital Communications Conference

Technical papers are solicited for presentation at the 27th Annual ARRL and TAPR Digital Communications Conference to be held September 26-28, 2008 in Chicago, Illinois. These papers will also be published in the Conference Proceedings (you do NOT need to attend the conference to have your paper included in the Proceedings). The submission deadline is July 31, 2008. Please send papers to:

Maty Weinberg
ARRL
225 Main St
Newington, CT 06111

or you can make your submission via e-mail to: maty@arrl.org

Papers will be published exactly as submitted and authors will retain all rights.

73 ... Steve, WB8IMY
ARRL

AMSAT's New Spacecraft Integration Lab After 14 Months

Robert Davis, KF4KSS, and J.C. Taylor, W3JCT

Part I

March 2008

For over a year, AMSAT volunteers (and Hawk Institute for Space Sciences (HISS) employees) have been working to bring the new AMSAT Spacecraft Integration Lab in Pocomoke City, Maryland, to an operational status. This report provides answers to some simple questions that have been asked by both AMSAT members and HISS personnel.

AMSAT: "Where are we going to integrate and test Eagle?"

HISS: "What can we do cooperatively with AMSAT?" (I was usually the one asking this.)

Many meetings and a couple of memorandums of understanding later, the lab moved from Orlando, Florida (of AO-40 and multiple hurricanes fame) was moved lock, stock and barrel to Pocomoke City during the holidays of 2006. Most of the lab stuff was in storage units, and the clean room had been disassembled and moved into a different storage site near Kennedy Space Center.

So many people have done a good job of keeping the *The AMSAT Journal* current, during my months of silence. My thanks to them!

Many of you will remember fragments of this story from our president's articles and from several others that have given updates while I sat silently (working hard though).

On the pages that follow are photographs I've taken over the past 14 months at the new lab. I've selected only the best few and I hope you find them interesting too.

Where is Pocomoke City?

We're about 2.5 hours southeast of Washington, DC, on the Eastern Shore of Maryland on the DelMarVa peninsula.

Why Pocomoke City?

My employer, the Hawk Institute for Space Sciences, is interested in cooperative activities with AMSAT. HISS offered to host AMSAT's lab in exchange for being able to use "excess equipment". The arrangement is working out very well for both parties! HISS is affiliated with the University of Maryland Eastern Shore and most of us employees (engineers) are contracted to support NASA Wallops Flight Facility.

UMES may be a good venue for AMSAT's educational outreach.

The NASA Wallops Flight Facility has a variety of test facilities suitable for spacecraft. These include an anechoic chamber, thermal vacuum chambers, vibration tables and spin balance and mass properties tables.

What do we have?

The HISS lab and machine shop total about 4,000 square feet. AMSAT has done a good job of planting a flag by providing and assembling the 20 ft by 20 ft clean room.

Through the significant efforts of a number of local and less-than-local volunteers, the lab contents have been inventoried, cleaned, organized and then cleaned again (don't ask why). Actually, in fear of retribution from the dedicated individuals that did all that cleaning, stripping, priming and painting, I better not gloss over it!

AMSAT has:

- 1) Refurbished and made operational a 20'x20' clean room for spacecraft assembly, integration and testing. The clean room has HEPA filters which should provide significantly better than class 100,000 cleanliness. The clean room was re-assembled using static-dissipative clear walls so that sensitive electronics are safe even close to the walls. We'll use the clean room for SuitSat-2 solar panel assembly, the Eagle spacecraft and everything related to the potential rideshare with Intelsat to geostationary orbit.
- 2) Flow bench. This single user station maintains clean circulation over objects that are being prepped for entry into the clean room or are small enough to not need entry into the clean room. It is attached to the exterior of the clean room and can act as a pass-through.
- 3) Vacuum bell jar. This little gem allows us to test objects up to about a cubic foot in a vacuum. This can be used to test individual boxes like SuitSat-2 or electronics that will then be placed into a spacecraft.
- 4) Various ground station equipment: Icom 910H, Icom 251A, Icom 451A, Kenwood TS-950SD, two computers and various TNCs and accessories. After an investment from HISS for the tower erection and antennas, we'll have a very capable ground station!
- 5) Two electronics workbenches with

power supplies, minimal test equipment and lots of spares remaining from AO-40 construction.

- 6) Many valuable tools, hardware and documents from previous projects.
- 7) A core team of volunteers that have shown up on Saturdays for over a year, even when we haven't done any ham radio. That's hard-core dedication!

The Pocomoke City facility is only 15 minutes away from two other useful sites: the University of Maryland Eastern Shore campus and NASA Wallops Flight Facility. UMES may be a good place for our educational outreach efforts and may be a valuable asset as we do educational outreach to others who need support & facilities. AMSAT isn't a stranger to NASA Wallops Flight Facility as Bob McGwier, N4HY, pointed out that P3A was spin-balanced here in 1980!

What are we doing?

We've spent over a year working on "facilities". That was fun and I'm glad it's almost over! We will now move our attention to the ground station, Eagle and other projects. There's still reconditioning of other equipment here at the lab to be completed, but we can see the light!

What do we need?

- 1) Volunteers on AMSAT projects (at the lab and also scattered across the U.S.). Contact AMSAT if you're interested in participating!
- 2) Donations of test equipment, and supplies! These donations can be personal or corporate. Donations are tax deductible!

In the last year, we've received a number of valuable donations. Everything from the Icom910H and accessories, to shipping containers and 19" racks. Let us know if you have anything you'd like to add to that list.

When do we meet?

Volunteers are welcome most Saturdays from 9 AM until 5 PM. If you find yourself in the area, contact me at KF4KSS@amsat.org for more information or to RSVP as a volunteer.

Keep an eye out in future *AMSAT Journal* issues for more news!

73,
Bob



Part II

Welcome to AMSAT Pocomoke

When Bob Davis, AMSAT Laboratory Coordinator, asked me to co-author a paper I thought what could I offer the AMSAT readers? My answer to the question may seem a little odd to a highly technical reader group, but I would like to officially welcome AMSAT to the Pocomoke and the greater area of the Delmarva Peninsula. This peninsula is nestled between the Chesapeake Bay and the Atlantic Ocean. Delmarva gets its name from the states of Delaware, Maryland, and Virginia. We generally refer to ourselves as an Eastern Shoreman. The peninsula is surrounded by metropolitan areas like Philadelphia, Wilmington, Baltimore, Washington D.C., Richmond and Norfolk, yet the area is largely rural, agricultural and maritime based. So, speaking as an Eastern Shoreman let me be the first to officially welcome AMSAT and its members to the Pocomoke facility.

I think this peninsula has a lot in common with the spirit that we seek in AMSAT and the AMSAT laboratory. The area dates back to the beginning of our country with people from many walks of life seeking adventure and new beginnings. The names of our rivers, counties and towns reflect a lot about

who we are. The Native Americans named the Pocomoke, Wicomico and Manokin Rivers and yet our counties of Worcester, Dorchester and Sussex reflect the origins of the early settlers. I live in the City of Salisbury on the Wicomico River. The rivers and bays produce the famous blue crab, oysters and rockfish. Lined by tidal grasslands and tuckahoe's, the rivers still form an avenue for trade and goods. My QSL card pictures the Skipjacks, which are sailing vessels unique to the Chesapeake Bay used to dredge oysters. The earth provides soybeans, corn, tomatoes and watermelons for our farmers, while the meadows and forest abound with quail, ducks, geese and deer.

I first met Bob after most of AMSAT's worldly possessions arrived at the Pocomoke warehouse after a trip from Florida in early 2007. Equipment lay everywhere in the warehouse and there was nothing that looked like a lab until you met Bob. Bob could see offices, laboratories, clean room and a machine shop. What I saw included large air handling boxes that needed a lot of work. Test equipment and parts (some of which had names hard to pronounce) lay everywhere. Just as those early settlers came from many

walks of life, so did the volunteers. We are young and old, fathers and daughters, hams, retirees and students. We wash, we scrub, we sand and we paint with visions of satellites dancing in our heads. It's not all work thanks to Bob's dreams. At lunch we talk about the ground station, Eagle, the electronics and the construction. We talk of satellites past and satellites future. We even had time last summer to help at the SimSat space camp at the University of Maryland Eastern Shore campus where a balloon project captivated young and old. For those of you who talk to Bob the engineer on conference calls or saw Bob at the Pittsburgh symposium, then you have only met part of Bob. I see Bob the painter (he should keep his day job), the carpenter, machinist, anti-static panel preparer for the clean room and electrician (????). Yet in everything we do we see the end product.

Now, here we are a year later and we see offices, a lab, a clean room and a machine shop. The days of the cold warehouse, the scrubbing and painting may be behind us, but they make us appreciate the time, money, and sacrifice of those that came before us in AMSAT.

J. C. Taylor

W3JCT



Left: AMSAT possessions right after unloading.



Left: Taking part of the cleanroom off the truck. L to R: Fritz Stapf, Bob Davis, KF4KSS, Claude Treherne, Paul Shuch, N6TX, Rick Hambly, W2GPS, Drew Glasbrenner, KO4MA.



Right: Scrubbing cleanroom parts - L to R: Rob Renoud, K3RWR, JC Taylor, W3JCT.



Left: Cleanroom assembly - L to R: Bob Davis, KF4KSS, Ray Fantini, KA3EKH, Claude Treherne.



Right: First inventory at the new lab - L to R: Rob Renoud, K3RWR, Drew Glasbrenner, KO4MA, Rick Hambly, W2GPS.





Hawk Institute for Space Sciences

Flight Log

November / December 2006

UMES & Hawk Institute Sign Agreement with AMSAT-NA to Build Satellite Projects on Maryland's Eastern Shore

The University of Maryland Eastern Shore community welcomes AMSAT-NA to the Eastern Shore as the two groups agree to work jointly on satellite and related technology projects in the region. The Hawk Institute for Space Sciences (HISS), through its parent company Maryland Hawk, has signed a Memorandum of Understanding with AMSAT-NA to host AMSAT spacecraft integration lab at the HISS facilities located in the Mid-Atlantic Institute for Space and Technology (MAIST) building in Pocomoke City, Maryland.

AMSAT-NA, formally known as the Radio Amateur Satellite Corp, is a non-profit 501(c)(3) volunteer organization whose mission is to design, build and operate experimental satellites carrying amateur radio payloads and promote space education. AMSAT has designed and built over 30 satellites carrying amateur radio equipment since its founding in 1969.

The agreement with Maryland Hawk gives AMSAT-NA essentially no-cost access to the HISS facility in return for sharing its equipment and ideas with HISS. The agreement also allows for AMSAT's portable clean room and other resources to be located at the HISS facility. Hawk and UMES will provide volunteer labor for the AMSAT Eagle satellite project, and AMSAT will share their spacecraft technology with the University community.

UMES has signed an independent Memorandum of Understanding with AMSAT-NA to work collaboratively to identify opportunities to develop appropriate satellite and related technology projects, as well as working with UMES students and faculty to enhance hands-on studies and dissertation research. AMSAT-NA scientists and engineers may receive Adjunct status at UMES.

Jerry Redden, Worcester County Director of Economic Development, says "this agreement is a win-win for everyone involved."

"It opens doors to the aerospace for our native sons and daughters. We've been working with area high school and college students to excite them in science, technology, engineering and math, and this partnership provides opportunities to students on the Eastern Shore to enter the knowledge-based economy," says Redden.

AMSAT-NA includes the United States and Canada, and other AMSAT organizations exist throughout the world. Membership in AMSAT-NA is approximately 4,000 individuals.

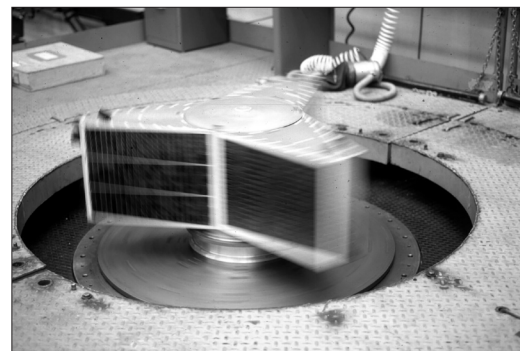
See <http://www.amsat.org> for more information about AMSAT-NA. If you would like to be a volunteer on AMSAT-NA's next satellite project, named Eagle, contact Bob Davis at bdavis@mdhawk.org.

Hawk Institute for Space Sciences is a Division of the Maryland Hawk Corporation, an affiliated 501 (c) (3) non-profit organization of the University of Maryland Eastern Shore, a Historically Black 1890 Land-Grant University.



University Officials Meet with AMSAT-NA Directors

Front row (L to R): Rick Hamblly, President of AMSAT-NA and member of the AMSAT-NA Board of Directors; Dr. Thelma Thompson, President, University of Maryland Eastern Shore, and Quentin R. Johnson, Executive Assistant to the UMES President; Back row (L to R): Dick Jamison, volunteer AMSAT-NA engineer; Bob McGwier, Vice President of Engineering for AMSAT-NA and member of the AMSAT-NA Board of Directors; Dr. Ronald G. Fortydyke, Vice President for Planning, Assessment, Technology and Commercialization for UMES; Ron Settem, Executive Director of Hawk Institute for Space Sciences; Tom Clark, member of AMSAT-NA Board of Directors; and Robert Davis, engineer with HISS and volunteer AMSAT-NA engineer.



Above: P3A Spin Balance at NASA Wallops Flight Facility in 1980, courtesy Bob McGwier, N4HY.



Above: Half-scale Eagle model at Space Day 2007 National Air & Space Museum with Bob McGwier, N4HY.



Above: Model of Eagle as fundraiser at AMSAT Annual Space Symposium.



Three views of the cleanroom - left, front and rear.



Above: Machine shop (never again will it be this pristine).



Above: Ground station (radios ready, but tower is not up yet).



PROCEEDINGS OF THE AMSAT-NA

2007 Space Symposium and AMSAT Annual Meeting

Pittsburgh, PA

This is a must for anyone who was not able to attend the 2007 AMSAT Symposium in Pittsburgh or those who attended and would like the Proceedings on DVD.

This DVD has all of the 2007 papers, PowerPoint presentations, illustrations and audio of the presentations. Additional features include the Symposium papers from 2004 and 2005 plus ISS Columbia module video and much more.

Now Available!

To Order: Proceedings - 2007
(DVD)

Write, telephone or FAX:

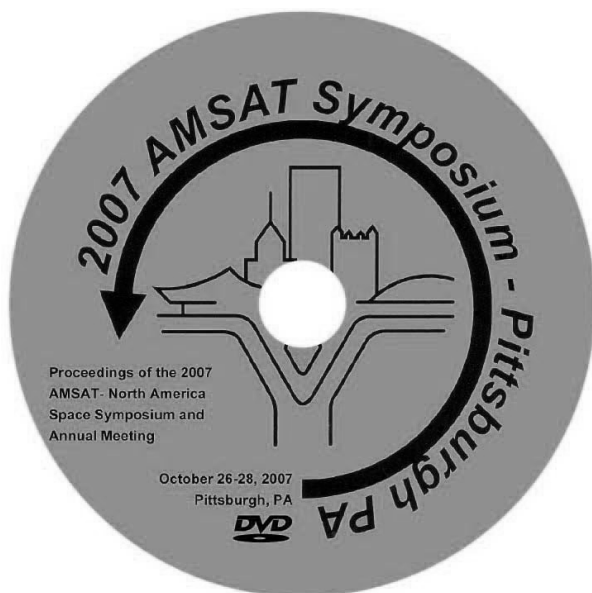
AMSAT-NA

850 Sligo Ave. #600
Silver Spring, MD 20910, USA

Tel: 301-589-6062
Fax: 301-608-3410

Minimum donation

\$30 in the U.S. + postage.
VISA, MasterCard or Discover charges are accepted.



THE R.F. CONNECTION

*"Specialist in
R.F. Connectors and Coax"*
<http://www.therfc.com>

301/840-5477
Fax 301/869-3680
E mail: rhc@therfc.com

Order Line 800/783-2666
Suite 11, 213 N. Frederick Ave.
Gaithersburg, MD 20877



A Second Life for AO-16: Crash – Recovery – Rebirth

Mark Hammond, N8MH, n8mh@amsat.org

Jim White, WD0E, wd0e@amsat.org

and Bruce Rahn, WB9ANQ, wb9anq@amsat.org

Introduction

AMSAT OSCAR 16 (also known as PACSAT, designated as AO-16, NORAD number 20439) suffered an unknown failure that caused it to cease transmissions in May 2007. The satellite was partially recovered in November 2007 and was reconfigured into a novel new voice mode (V-FM/U-DSB) in January 2008. The formerly “digital only” satellite remains open to Amateur Radio operators in this new voice mode.

The purpose of this article is to provide an update on the status of AO-16 and to explain its new mode and current operation as a voice satellite.

Background on PACSAT AO-16

The successful launch of four microsatellites—AO-16, DO-17, WO-18, and LO-19—on January 22, 1990 remains one of the most memorable events in AMSAT history. These four low earth-orbiting satellites (or LEOs) marked the beginning of a new era for AMSAT.

Although the concept of a packet radio satellite had been kicking around in the brains of AMSAT’s “movers and shakers” since 1981, it wasn’t until one of those famous AMSAT “after hour’s meetings” that all the pieces fell in place. Tom Clark, K3IO, Jan King, W3GEY, Phil Karn, KA9Q, and Bob McGwier, N4HY found themselves meeting in a hotel room after the November 1987 AMSAT Symposium banquet. Jan

talked with the group about an idea he and Gordon Hardman, KE3D, had been thinking about for a simple satellite. The concept was indeed simple: a very small, 9 inch cube satellite built from several stackable modules. But what could be done by such a small satellite? Well, by 3 AM this group had developed a preliminary design for a packet radio satellite, allocated functional/physical requirements to each module, selected a candidate CPU, and completed link margin calculations to prove the concept would work. [1] And, as they say, the rest is history!

AO-16 is comprised of five stackable modules, which are, from top to bottom:

- Receiver Module: Five FM receiver IF strips, based on the MC3362 low-power, narrow band FM receiver IC sharing a common local oscillator, GaAsFET preamp, helical filter and antenna.
- S-Band Transmitter Module
- Battery Charge Regulator (BCR)/ Battery Module: 8 cell, 6 AH NiCd pack rated to operate at temperatures up to 70 degrees C and the associated electronics to “condition” the power from the solar arrays to charge the battery pack and provide power to the other modules.
- CPU Module: NEC V40 CPU, 2k bytes of ROM containing the Microsat Boot Loader (MBL) code, 256k bytes of 12 bit error detecting and correcting

(EDAC) RAM, 2M bytes of bank switched general purpose RAM and 6M bytes of RAM configurable as RAM disk.

- Transmitter Module: One standard PSK transmitter and one raised cosine PSK transmitter sharing a common antenna.

An innovative five-wire serial communications bus interconnects the five modules. The bus, based on the MC14469F addressable asynchronous receiver/transmitter (AART) IC, was the first implementation of a serial communications bus in an AMSAT-NA spacecraft eliminating the need for the traditional bulky and hard to fabricate point-to-point wiring harnesses employed in previous AMSAT spacecraft.

A more complete story of the fascinating development, configuration and on-orbit performance of the Microsats may be found in the references cited at the end of this article. [2], [3]

The Crash

After approximately 2700 days of continuous operation since its last software reload, AO-16 was reported as silent around May 22, 2007. In October, an AO-16 recovery team consisting of three core members formed: Jim White, WD0E, Bruce Rahn, WB9ANQ, (both former Microsat command team members), and Mark Hammond, N8MH (a digital satellite enthusiast). Invaluable support was also provided by familiar AMSAT legends and a list including those that contributed to the recovery efforts is included in the acknowledgment section of this article.

At the start of the recovery efforts the reason for the silent state of AO-16 was not known. Possibilities ranged from minor software issues to a complete hardware failure leading to the end of the mission. Initial efforts to turn on the two U-band transmitters (437.025 MHz and 437.050 MHz) and S-band transmitter (2401.200 MHz) were unsuccessful suggesting that the satellite was no longer running its housekeeping task software or that a significant hardware failure had occurred. Hoping for the former case, it was assumed that the AO-16 housekeeping software had crashed and the satellite had

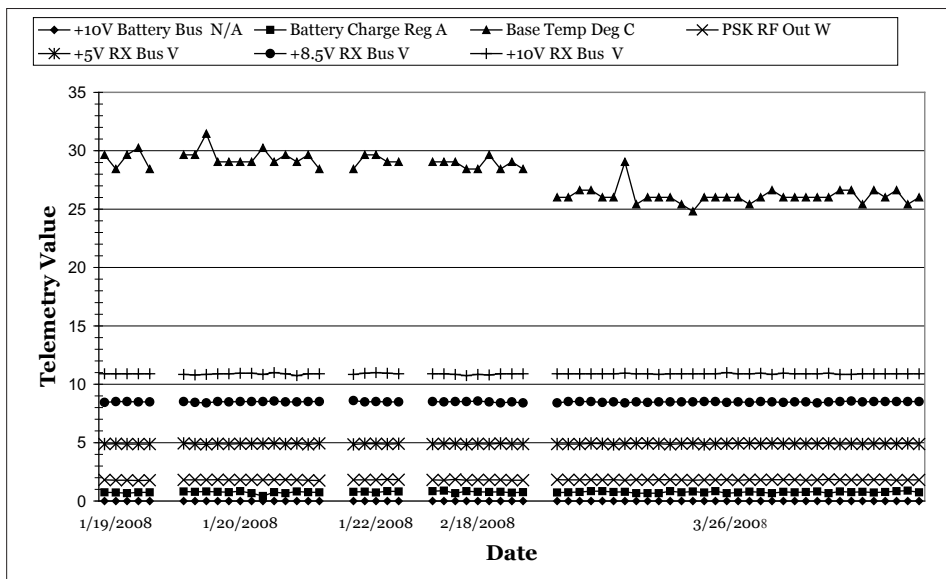


Figure 1: AO-16 MBL telemetry samples.



rebooted into the Microsat Boot Loader, or MBL. The MBL runs from a Read Only Memory or ROM device on the satellite and provides access to very basic systems of the satellites, such as transmitter and receiver configurations.

Controlling the spacecraft from MBL is challenging—it is very similar to the operation of ancient digital computers with their rows of toggle switches. Through some very basic ground station control software, the command operator, in essence, sends an on/off setting for these virtual switches to the spacecraft. And if that isn't challenging enough, you have to know all of the previous switch settings before you can safely change things—there is no feedback to show you what was done before. It's a slow process to go through to ensure the command operator has everything set properly!

The Recovery

On November 8, 2007, the 437.025 MHz PSK Transmitter "A" was successfully commanded back ON by N8MH, confirming suspicions that AO-16 had been running in MBL. Initial reports of the received signal were excellent, and its loud PSK audio was easily heard. Simple MBL telemetry from AO-16 could be heard and copied by a TNC in KISS mode on the downlink.

The MBL telemetry is fairly simple and does not give a complete view of the satellite's systems. Furthermore, the telemetry sent by the satellite running in MBL mode is not transmitted on a regular time interval. However, some telemetry is better than NO telemetry! To facilitate analysis of the

available telemetry, an excellent and user-friendly MBL telemetry decoder was quickly developed by Mike Rupprecht, DK3WN. Mike's AO-16 MBL Telemetry Decoder program (and many others!) is free and available for download from his Web site at <http://www.dk3wn.info>.

There are 7 frames of telemetry data sent by AO-16 when running in MBL. These telemetry channels are:

- +10V Battery Bus Voltage, which is nonfunctional and thus generates a value of "0"
- Battery Charge Regulator Current
- Base Plate Temperature
- PSK Transmitter RF Output
- +5V Receiver Bus Voltage
- +8.5V Receiver Bus Voltage
- +10V Receiver Bus Voltage (a near duplicate of the first channel)

Sample MBL telemetry from January, February and March 2008 is presented in Figure 1.

As the base plate temperature telemetry values in the above sample indicate, the satellite appears to be running a tad on the warm side. Figures 2a and 2b show the illumination data for AO-16. Taking into account that AO-16 has been in full illumination (no eclipse) since August 15, 2007, this comes as no surprise.

Using John Magliacane's excellent PREDICT program, which can be freely downloaded at <http://www.qsl.net/kd2bd/predict.html>, we see that AO-16 should begin experiencing eclipse periods on March 30, 2008.

Reload Attempts

Shortly after the PSK transmitter had been turned back ON, multiple (nearly a dozen) attempts to upload and execute the satellite housekeeping software were made. Results varied from an immediate termination of the code to a couple of instances where the code ran for several seconds. In all trials, the satellite code terminated and the satellite returned to MBL. Our inability to keep the spacecraft running the housekeeping software for longer than a few seconds suggested that some portion of the craft has failed. In one attempt, the code executed long enough to result in the transmission of a full telemetry frame. That single frame is presented in Table 1.

EDAC Memory Testing

The failure of an 18 year old spacecraft to execute its housekeeping code could be the result of many problems. Knowing that the CPU and MBL in AO-16 are functional, spacecraft memory became the likely suspect in our current problem with running the satellite housekeeping code. Several simple experiments were conducted to test, in a very basic way, the EDAC memory of AO-16. The EDAC memory is where the housekeeping software is loaded. The EDAC memory on AO-16 is 256k bytes in size. Learning about the integrity of this memory is important for current and future recovery efforts of AO-16.

Binary files were created containing simple bit patterns (01010101 binary or hexadecimal 55, and 10101010 binary or hexadecimal AA) for use in testing. These were uploaded into four different address areas of the EDAC memory. The files were uploaded then downloaded and compared to the original files. The results were enlightening. In some cases, only a single error was noted. In others, there were multiple bit errors. The errors did not occur at the same locations every time. But what could be causing the errors? Their nature and pattern suggests that they were not the result of single bit flips caused by charged particles (Single Event Upsets or SEUs).

Sample EDAC memory test results for AO-16 are presented below in Table 2a and Table 2b.

Downloading the same memory area multiple times yields the same result; the errors do not appear to change, even after several days in orbit.

In several memory experiments where a

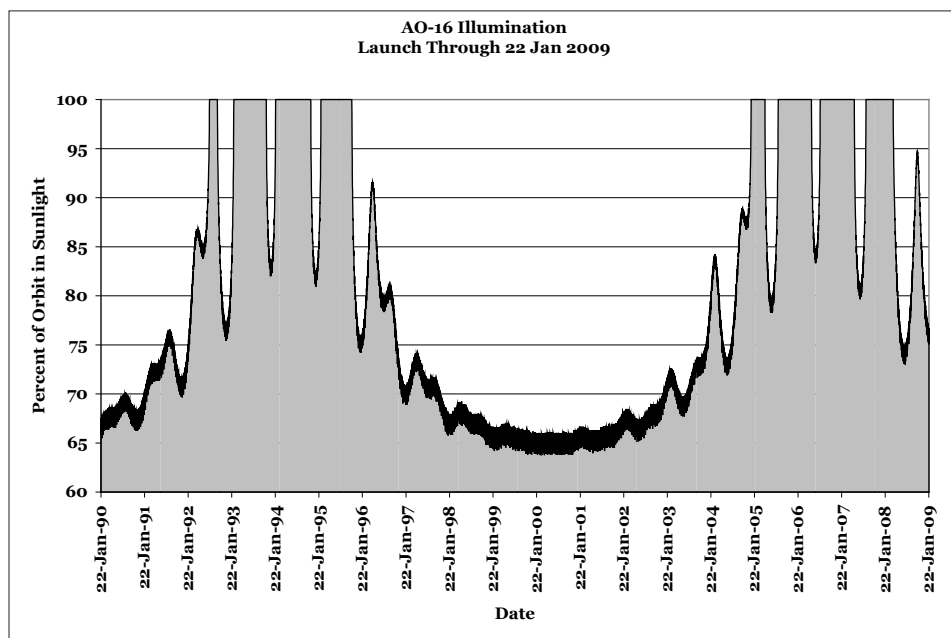


Figure 2a: AO-16 Illumination from Launch to January 2009.



memory error was noted, a short file was uploaded to overwrite those memory areas and then the data from these memory areas were again downloaded. In each case, the small downloaded file matched precisely the source file (i.e., expected and observed values were in agreement at all addresses). Therefore, the results of these simple “re-write” memory tests suggest that the memory itself does not appear to be damaged. Rather, our results demonstrate that the satellite is randomly writing incorrect data to memory. While the cause of the errors is not known, one possible cause is a data bus line driver integrated circuit that no longer meets performance specifications due to accumulated radiation exposure.

In summary, our observations from the simple memory testing include the following:

1. Sometimes code uploaded precisely matches the code when downloaded. Other times, there are errors.
2. The errors are beyond a reasonable expectation for normal SEU caused bit flips.
3. The address locations of the errors are random.
4. The errors can be overwritten.
5. The errors have been observed across a range of addresses.

Conclusions from the simple memory testing include the following:

1. The EDAC memory itself is not permanently damaged. Rather, a failure somewhere in the hardware that writes

to the EDAC memory makes its use no longer possible. The specific location of the hardware failure is not known and cannot be determined.

2. We conclude that AO-16 is no longer able to run its housekeeping task software (which is necessary to produce full telemetry and to provide digipeater functions) or the PBBS software (which is necessary to use the store and forward digital file system).

A 17 year lifetime for the full functions from a satellite with an expected useful lifetime of 5 years speaks well of the engineering, designing, construction and commanding of this very fine bird.

Rebirth: Teaching an Old Bird a New Trick

On January 16, 2008, Jim White, WD0E, sent to the Pacsat Command Operators mailing list an email that described the ability of AO-16 to repeat received bits from any receiver to the PSK transmitter. Jim stated, “It’s not an FM repeater but a digital repeater. I don’t know that we ever tried that. Might make an interesting mode.” And indeed, what an interesting mode this turned out to be!

Thanks to Tom Clark, K3IO, AO-16 has five very sensitive receivers that are under the control of the AART system. Additionally, during the receiver designing stage Tom made a provision that allows the rerouting of audio out of a receiver directly into the PSK transmitter—a feature primarily included to facilitate testing during satellite integration.

Those decisions—the AART system and the ability to reroute the raw receive audio—are pivotal to the current operation of AO-16 as a voice repeating satellite.

On January 20, 2008 (during orbit number 93,957—two days before its 18th birthday!) AO-16 was commanded into a new, untried repeater mode. Essentially, the audio output of the receiver is rerouted straight to the PSK transmitter. In this configuration AO-16 retransmits, as a double sideband/reduced carrier transmission, all received audio from the selected FM receiver. The result is a new and unique satellite mode, V-FM/U-DSB.

On the first pass in this mode, initial tests between N8MH and KO4MA were digital; a packet was uplinked to the 145.920 receiver and retransmitted on the 437.0250 PSK transmitter. Indeed, it worked! While serving as a proof of principle experiment, it became obvious that operations in this mode included some challenges that make its use a bit awkward (e.g., uplinking was Manchester encoded, and so now is the downlink. Most satellite PSK modems are configured for Manchester encoding on the uplink only). On the next pass, while continuing the packet testing in its new configuration, KO4MA and N8MH heard non-amateur voice transmissions coming through AO-16’s transmitter! KO4MA and N8MH both grabbed madly for their microphones, plugged them in, and held what is likely to be the first voice QSO through one of the digital microsats. Serendipitously, AMSAT Corporate Secretary/VP for Special Projects Barry Baines, WD4ASW, was in the N8MH shack during this historic pass and contributed to the first round-robin QSOs. The result of this test on AO-16 was rather amazing, and thus a dying digital bird was reborn as a voice satellite.

The current mode of 2M FM voice uplink and 70 cm DSB downlink presents a few minor obstacles. The Doppler shift at a 70 cm frequency in SSB mode on a LEO can be quite a challenge, and it appears that some small corrections for Doppler of the 2M FM uplink frequency are helpful as well. The great news is that the DSB downlink signal is fairly easy to hear from horizon to horizon, and many amateur operators already have the necessary equipment (a 2M FM transmitter and 70 cm SSB receiver) to use AO-16 in its new mode.

The Future

No one can predict the future—AO-16 may be alive and well after another 18 years of

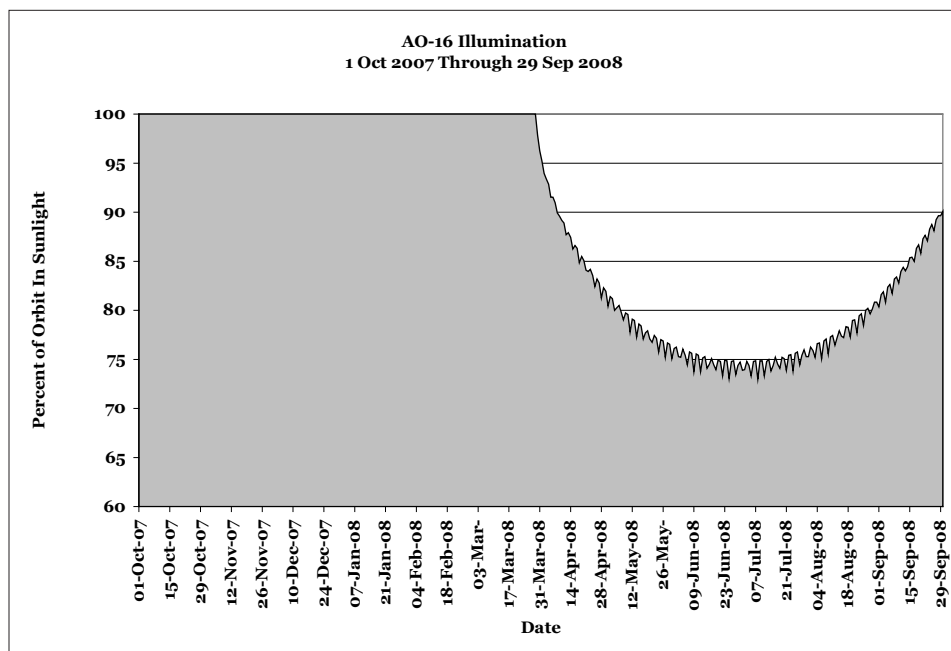


Figure 2b: AO-16 Illumination—October 2007 through September 2008.



service or something could fail tomorrow causing the bird to go silent forever. However, we can assess AO-16's overall health based on the most recent frame of full telemetry data by comparing that data to one from almost 12 years earlier as shown in Table 3. From this we can formulate some thoughts about what the future may hold.

With the exception of the spacecraft memory issues noted earlier, AO-16 appears to be in very good overall health. The most critical set of parameters dealing with continued operation are those related to the spacecraft battery. We know that the ability of the battery pack to hold a charge has degraded over time. This was evidenced several years ago when it became impossible to operate the UHF and S-Band transmitters simultaneously through an eclipse. How much additional degradation has occurred is unknown and will never be fully known, but some rough order of magnitude estimation will be possible as AO-16 enters periods of eclipse again. However, the fact that the individual cell voltages are fairly well balanced and that the overall battery pack voltage is close to

And as we enter periods of eclipse, we anticipate these values will drop closer to nominal values as the duration of the eclipse periods approach those seen for the first several years of operation.

Future AO-16 operations will require more care and feeding from command stations since all housekeeping functions will have to be performed manually. The condition of the battery pack will

PHT: uptime is 000/00:00:04				PACSAT	
Rx A DISC	0.544 k	Rx A S meter	108.000 C	+5V Rx Current	0.064 A
Rx B DISC	2.060 k	Rx B S meter	152.000 C	LO Monitor I	0.002 A
Rx C DISC	3.149 k	Rx C S meter	135.000 C	GASFET Bias I	0.003 A
Rx D DISC	-0.867 k	Rx D S meter	145.000 C	Rx Temp	27.228 D
Rx E/F DISC	2.789 k	Rx E/F S meter	146.000 C	Ground REF	0.000 V
+5 V Bus [RX]	4.911 V	+8.5V Bus [RX]	8.524 V	+10V Bus [RX]	11.000 V
+5V Bus	4.955 V	+8.5V Bus	8.566 V	+10V Bus	10.532 V
+5V Bus Cur	0.202 A	+8.5V Bus Cur	0.021 A	Array V	20.617 V
Bat 1 V	1.343 V	-X Array Cur	-0.010 A	+Z Array V	21.688 V
Bat 2 V	1.323 V	+X Array Cur	0.040 A	BCR Load Cur	0.328 A
Bat 3 V	1.349 V	-Y Array Cur	-0.019 A	BCR Output Cur	0.317 A
Bat 4 V	1.319 V	+Y Array Cur	0.163 A	BCR Input Cur	0.229 A
Bat 5 V	1.335 V	-Z Array Cur	-0.018 A	BCR Set Point	124.619 C
Bat 6 V	1.379 V	+Z Array Cur	0.036 A	Bat 1 Temp	30.253 D
Bat 7 V	1.344 V	+Z Array Temp	25.413 D	Bat 2 Temp	28.438 D
Bat 8 V	1.349 V	+Y Array Temp	28.438 D	Basepl't Temp	29.648 D
+2.5V VREF	2.506 V	+X (RX) temp	26.018 D	IR Detector	36.000 C
PSK TX RF Out	1.078 W	RC PSK TX Out	0.005 W	S band TX Out	-0.009 W
PSK TX HPA Tem	28.438 D	RC PSK HPA Tem	26.018 D	S band HPA Tem	158.000 C
		RC PSK BP Temp	25.413 D		
Array C = 0.239; Array P = 4.921; Bat Ch Cur = -0.012; Ifb = -0.009; I+10V = 0.338; TX: 1007; BCR: 80; PWRC:59B; BT:3C; WC: 0; EDAC:CB; Q = Quit, space to continue					

Table 1. Telemetry produced by AO-16 on December 17, 2007 during the 2118 UTC pass.

Address	Expected		Observed	
hex	hex	bin	hex	bin
1000:4A01	55	01010101	95	10010101
1000:4A08	55	01010101	59	01011001
1000:4A12	55	01010101	59	01011001
1000:4A80	55	01010101	4C	01001100
1000:4A81	55	01010101	CF	11001111
1000:8186	55	01010101	95	10010101

Table 2a: AO-16 EDAC memory test results for memory block 0x1000.

have to be carefully monitored to ensure a break-even to positive power budget is maintained. The power budget will be maintained through the manual adjustment of the transmitter output power in eclipse period duration and solar cell illumination angles.

nominal are very encouraging and bode well for a promising future.

The receiver current has increased slightly over nominal, but is of no great concern as it is most likely due to the higher receiver temperature. The +5V and +8.5V bus currents are lower than expected since the housekeeping and PBBS software is not running and all of the RAM is in an idle state.

The most noticeable difference between the two snapshots is the temperature values of several of the internal assemblies. They are running about 23 to 29 degrees C warmer with the satellite in a period of full illumination. Even at these significantly higher temperatures, the battery pack is still well within its operating specifications.

Operation of this old war horse long into the future in its new repeater mode looks bright! Not bad at all for a satellite designed, developed, fabricated, and operated by a bunch of Amateur Radio operators using commercial/industrial grade-off-the-shelf components. It speaks highly of AMSAT and of all those dedicated volunteers who poured their blood, sweat and tears into this program over the years. Thank you, each and all, for a job WELL DONE!

Address	Expected		Observed	
hex	hex	bin	hex	bin
3000:00C5	AA	10101010	A6	10100110
3000:00C6	AA	10101010	A9	10101001
3000:00D1	AA	10101010	9A	10011010
3000:00FF	AA	10101010	9A	10011010
3000:0104	AA	10101010	A9	10101001
3000:0114	AA	10101010	9A	10011010
3000:0123	AA	10101010	A9	10101001
3000:012A	AA	10101010	9A	10011010
3000:0133	AA	10101010	A9	10101001
3000:0136	AA	10101010	9A	10011010
3000:0138	AA	10101010	9A	10011010
3000:0139	AA	10101010	9A	10011010

Table 2b: AO-16 EDAC memory test results for memory block 0x3000.



Telemetry Parameter	Reading Dec 17, 2007	Reading Jan 2, 1996
+ 5V Bus [RX]	4.911 V	5.002 V
+ 5V Bus	4.955 V	5.004 V
+ 5V Bus Current	0.202 A	0.320A
+ 8.5V Bus [RX]	8.524 V	8.563 V
+ 8.5V Bus	8.566 V	8.661 V
+8.5V Bus Current	0.021 A	0.037 A
+10V Bus [RX]	11.000 V	11.050 V
+10V Bus	10.532 V	10.923 V
Battery 1 Voltage	1.343 V	1.328 V
Battery 2 Voltage	1.323 V	1.379 V
Battery 3 Voltage	1.349 V	1.374 V
Battery 4 Voltage	1.319 V	1.428 V
Battery 5 Voltage	1.335 V	1.352 V
Battery 6 Voltage	1.379 V	1.445 V
Battery 7 Voltage	1.344 V	1.403 V
Battery 8 Voltage	1.349 V	1.398 V
+5V RX Current	0.064 A	0.043 A
LO Monitor Current	0.002 A	0.002 A
GASFET Bias Current	0.003 A	0.003 A
RX Temp	27.228 deg C	-2.422 deg C
Bat 1 Temp	30.253 deg C	4.839 deg C
Bat 2 Temp	28.438 deg C	6.049 deg C
Base Plate Temp	29.648 deg C	3.629 deg C

Table 3: Key Telemetry Parameter Comparison for AO-16.

Acknowledgments

Bob McGwier, N4HY
 Courtney Duncan, N5BF
 Douglas Quagliana, KA2UPW
 Drew Glasbrenner, KO4MA
 Harold Price, NK6K
 Jeroen Vreeken, PE1RXQ
 - (<http://esther.esrac.ele.tue.nl/ao16/>)
 Mike Rupprecht, DK3WN
 Nick Pugh, K5QXJ
 Paul Williamson, KB5MU
 Russ Platt, WJ9F
 Tom Clark, K3IO

The entire Microsat team (<http://www.amsat.org/amsat/sats/nk6k/msatname.html>)

References

- [1] Clark, T., "AMSAT's Microsat/PACSAT Program", Proceedings of the AMSAT-NA Sixth Space Symposium and Annual Meeting, 1988, 4-5
- [2] Clark, 4-10
- [3] King, J.A., McGwier, R., Price, H., White, J., "The In-Orbit Performance of Four Microsat Spacecraft", The AMSAT Space Symposium Proceedings, 1990, 37-49. 🌐



Joe Spandler, K3SZH, (left) (AMSAT member #3788) is shown receiving an award at Central Pennsylvania Repeater Club luncheon. Lee Ash, K3JJK, presented the award to Joe for passing 50,000 contacts on AO-7 in January, 2008. (Thanks Marty Ginter, N3NZI, for the information and congratulations Joe! - Ed.)





Been thinking about working some birds?



Icom 910H **The perfect satellite rig**

Now that summer's on the way out, it's the perfect time to think about getting back to the shack and trying something way out. Work the amateur satellites - the OSCARs!

In 1961* the first amateur satellite, OSCAR 1, orbited Earth for nearly a week, putting ham radio right in step with the space age! In recent years, AMSAT® has launched some exciting amateur "birds" for the use of amateurs worldwide. The IC-910H is the perfect radio for satellite operation through new satellites such as ECHO, AO-51, and VUSat, VO-52!

OSCAR	Mode	Frequencies
AO-51	FM/PacSat	10m**/2m/70cm/23cm/12cm
VO-52	Linear (CW/SSB)	70cm/2m

Visit your Icom dealer today!

Free literature: 425.450.6088

or www.icomamerica.com

AMATEUR | AVIONIC | LAND | MOBILE | MARINE | RECEIVER | SYSTEM

ICOM®